THE INVESTIGATION OF
BUSINESS PROBLEMS

TECHNIQUE AND PROCEDURE

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DEDICATED TO

FREDERICK WINSLOW TAYLOR

whose pioneer work in the application of scientific methods to the study of business activities has greatly influenced the trend of modern management.

PREFACE

NECESSITY is said to be the mother of invention; however that may be, necessity has certainly been the incentive which brought about the preparation of this book. Starting with a collection of helpful ideas gathered from wide reading along scientific lines, and applied to the author's own work, this material first assumed tangible shape about 1919 in the form of instructions which were used in breaking in new research men in the department of which he was head.

About 1921 the idea suggested itself for expanding this material into book form, and since that time the author has worked as continuously on its preparation as time has permitted. Meanwhile, in order to insure the greatest practicability, the ideas and methods recorded herein have been tested under all sorts of circumstances and conditions in various types of industrial establishments.

In the preparation of this procedure, two distinct purposes have been in mind. First there is the fundamental intent to present a thorough analysis of the subject, one that is sound both from a standpoint of theory and practice. But back of the foregoing, and assuming primary importance at all times, is the purpose of developing a practical training in the art of investigation which will be of equal value to the business executive and to the research worker, both in the analysis and the solution of their problems.

Time and space are entirely lacking for giving proper credit for the assistance received in preparing this book. Substantially, the procedure is an adaptation of the scientific method applied to the solution of business problems. From Plato down to the present, the greatest minds of all ages have been studying the thinking process. From their writings on this subject, and from the practices of great scientists like Darwin, Huxley, and others, invaluable assistance has

been received, traces of which will be evident throughout this work; for thinking, after all, constitutes a major part of the investigational process.

Also, the author feels deeply indebted to his many friends in the industrial field. Without their helpful encouragement, this work would never have been started; and without the assistance which they have rendered from time to time in the shape of comments and criticisms, it could hardly have been carried through to completion.

But especially are thanks due to Erwin W. Runkle, Professor of Philosophy at the Pennsylvania State College, who has read the manuscript with especial attention to the treatment of logic and psychology; to Gilbert O. Ward, Technical Librarian, and Miss Florence M. Gifford, first assistant in the Reference Division of the Cleveland Public Library, who have read and commented on the chapter on "Bibliographical Research" and aided in the preparation of the bibliographies; and to Messrs. Hugo Diemer, Director of Industrial Courses of the LaSalle Extension University, E. O. Griffenhagen, President of Griffenhagen and Associates, Limited, and C. U. Carpenter, President of the Dayton Portable Typewriter Company, who have read the manuscript in its entirety and offered many helpful suggestions during its preparation.

J. Eigelberner

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with technical research, but more often it is concerned mainly with management problems, with the coordination of work, the determination of more economic methods and processes of manufacturing, and the improvement of working conditions.

Here, also, the larger and more progressive concerns have departments whose function is that of constantly studying manufacturing methods for opportunities to reduce the cost or increase output. Even the smaller concerns find it profitable to assign a competent man of an investigative turn of mind to the analysis of methods with a view to constant improvement. Even when no one individual is delegated to take care of this work, it still exists, for the executives in such cases are expected to investigate the work of their own departments and develop improved methods.

After all, this is, and perhaps always will be, the most usual way in which the investigation is utilized in business. But while fruitful in developing many improvements, it is obvious that much of this work is not as thorough or profitable as could be desired, principally because those entrusted with such investigational work do not know how properly to analyze and solve problems. When to the intimate knowledge of detail which such executives possess, is added a thorough understanding of the principles of investigation, the utility of this work can be greatly increased.

Internal investigation of this character does not require a laboratory, a special department, or even a staff engineer. It may be largely an attitude of mind, a point of view. The executive or worker who constantly asks himself "why" work is done a certain way is applying investigation. With proper training in the "how," this questioning attitude can be directed along profitable channels and lead to many valuable discoveries. Suggestion plans, properly administered, are excellent means for developing real investigational work in an organization.

But industrial investigations are not confined to manu-

facturing or commercial concerns. Insurance companies, railroads, and other public utilities employ thousands of special investigators, adjusters, and so forth, whose work is largely, if not wholly, investigational in character. The efficient performance of the work calls for accurate observation and gathering of data, together with careful analysis and logical reasoning from the data, all of which constitute essential elements in any sort of investigation.

Banks and financial institutions are also realizing more fully the value of thorough investigational work. For years the past records of concerns requesting financial assistance have been subjected to analysis. Events of late years have shown that while investigations of this type secure information that has informative value, yet it is still more important to know, as closely as possible, what is the potential earning capacity of these concerns.

Had the officers of the Fort Dearborn National Bank, in the years prior to 1920, investigated more carefully before making certain of their investments in the automotive industry, they would not have tied up such large amounts of capital in doubtful enterprises. Thus would have been avoided the financial embarrassment which developed during the depression, when it became necessary to liquidate these assets and it was found that they were practically worthless for immediate realization.

Today, therefore, the leading financial houses investigate not only the present financial condition of a business, but also the character and capacity of its management and its manufacturing and distributing policies. Thus, reasonable assurance of future growth and profits is had, and the depositors and stockholders of the banks are protected from possible loss.

For a similar reason, professional accountants are broadening the service that they render their clients. Formerly, it was their practice simply to audit the books of a concern and to prepare a balance sheet and income statement. Now

I

THE FIELD OF INVESTIGATION

Definition of investigation. Growing application to commerce and industry. Where investigation is commonly used. Technical and laboratory research. Industrial and management engineering. Commercial research and market surveys. Economic research. Executive decisions. Good research men are scarce. The need for an orderly training for research men.

INVESTIGATION is concisely defined by Webster as "The process of inquiring or examining into with systematic attention to detail and relationship." This involves the critical observation, accurate description, analysis and classification of the facts bearing on a problem; the systematic recording, tabulation, and orderly presentation of the data; and the development of a practical solution through logical processes of reasoning applied to the facts that have been observed and noted.

The first real application of investigation to industry was made by the late Frederick W. Taylor and the group of engineers who worked with him. In the profession of industrial or management engineering, which has grown out of Mr. Taylor's pioneer work, investigation received full recognition as a basic principle. How great have been the results secured through its intelligent application to our factories and workshops is apparent when present-day practice in most industries is contrasted with that of 10 or 15 years ago.

The great value of investigation having been so conclusively demonstrated in the field of production, it was not long before it was applied to other fields of business, until today it is recognized by industrial leaders that scientific investigation is the foundation of good management. Certain it is that consistent improvements in products and the use of ma-

terials can only be secured through that careful and persistent analysis and study which is summed up in the term "Investigation."

WHERE INVESTIGATION IS COMMONLY USED

Technical research is perhaps that phase of investigational work that has received the most attention from industrial executives. Many of the larger concerns maintain laboratories and research departments employing thousands of engineers and scientists who devote their entire time to experimental work. The Nela Park Laboratory of the General Electric Company and the General Motors Research Laboratory are examples that show what value "big business" ascribes to investigation. While in the smaller plants such extensive research work cannot be maintained, yet in the great majority of concerns at least one man will be found who devotes part, if not all, of his time to this type of work. In fact, it is a truism that every business which hopes to maintain its growth realizes that a certain amount of technical research must be undertaken so that the product or service may be improved to meet changing conditions.

Besides the great practical value of technical research, there is an element of romance about this work that maintains the interest. At any time a product, process, or idea may be developed which will revolutionize a certain industry. The Wahl Company, formerly well-known manufacturers of adding machines, through research developed an automatic pencil and put it on the market. So popular did this product become that the old product was soon given up and the activity of the business centered on the new development.

INDUSTRIAL ENGINEERING

Industrial or management engineering constitutes another phase of investigation. Sometimes this work is combined

EXECUTIVE DECISIONS

But there is still another field for the use of investigation which more closely concerns the executive than even the foregoing well-known uses. The average executive can easily see how the use of the investigational procedure is necessary in technical, industrial, and commercial research, but he does not often realize that he can apply the same procedure to his own work with equally beneficial results.

As it is realized, however, that men become successful in business in proportion as they are able to make profitable decisions and that such decisions can only be made by reasoning logically from an accurate knowledge of the facts, executives are utilizing investigation more and more so as to make certain that their decisions will be sound. No longer can they depend on hunch, intuition, or native shrewdness. They must investigate closely the problems which daily confront them, and upon their ability effectively to solve these problems depends their success. In this connection Henry S. Dennison, president of the Dennison Manufacturing Company, has stated that:

> A few years ago the idea of selecting raw material on a scientific basis was laughed at. In our factory the foremen were tearing tag stock with their fingers, and deciding arbitrarily that one sample was worth 6½ cents and another 6¾ cents. The producer of this tag stock was at their mercy and so was the manufacturing department. Today the testing of all our raw materials is done scientifically by means of instruments and chemical processes that admit of little error. The producer of raw material benefits through this investigation and our manufacturing department is able to turn out uniform products because of it.

And so it goes through all the divisions of business. The executive who knows how to investigate a problem can marshal his resources of information at a moment's notice, can bring them to bear on the subject, and can arrive at a profitable solution before one who has not mastered the investigational process can get fairly started.

In a recent interview, A. P. Sloan, Jr., president of the General Motors Corporation, gives some pertinent advice along this line as follows:

> Before I reach a decision of importance, I consult everybody who can possibly contribute to it, analyze their suggestions, formulate a tentative solution, and then invite the criticism of my associates. Usually when all angles of a question are before one, the solution comes automatically.[1]

Industry is dependent upon investigation for the facts which make possible its growth and development. Naturally, its use is spreading constantly, but it is greatly handicapped because of the difficulty of finding men and women who can efficiently carry on investigational work. To be able effectively to solve a problem calls for a knowledge of the technique and procedure of investigation, and up to this time but little real attempt has been made to train men and women for this work.

GOOD RESEARCH MEN ARE SCARCE

Lack of such a definite and orderly training has been responsible for many of the failures of investigational work in the past. Men have been assigned to investigate problems without being shown the proper methods of attack, the important things to consider, and the dangers to avoid. It has been expected that in some manner, from previous education, from reading, or from past experience, the ability to solve problems has been acquired. But that this is not the case can be vouched for by any executive.

A. W. Shaw, in his book *An Approach to Business Problems,* has admirably summed up the situation: "The trouble with a great many men in business is that they have no definite and ordered way of going at their problems. When a new situation or emergency arises, they take counsel with this man and that, waver from one view-point to another,

[1] *Industrial Digest,* April, 1925.

the better-known accounting firms are prepared to analyze the figures and to advise their clients regarding improvements in their methods of accounting that will aid in achieving better control.

COMMERCIAL RESEARCH

All of the foregoing work has been related to the manufacturing side of industrial activities. In later years, the necessity for reducing the cost of distribution brought about by the universal demand for greater values has forced many of the largest business establishments to engage in intensive marketing investigations so that sales plans and advertising campaigns could be based on accurate information as to consumption and demand, and not simply on guesswork.

The managing executives of an Ohio concern had for years based their sales plans on the belief that there were only 11 uses for a product. They were induced to investigate the subject, preliminary to undertaking an extensive advertising campaign. A questionnaire was sent out to customers and dealers, the answers to which brought out more than 300 uses. It can well be imagined how this information aided the management in preparing sales and advertising plans for the following year.

As yet, however, a very large amount of research work of this kind is handled by advertising agencies. In former years the emphasis was on the copy. Today the higher-grade advertising agency, before attempting to plan a campaign, makes a survey for the purpose of ascertaining the real demand for the product, the location of the market, its character, the buying appeals, and the salient selling points. With the information gained through this investigational work, profitable plans can be formulated for coordinating advertising and selling effort.

In all concerns, however, small or large, an ever-increasing percentage of the problems of management pertain to the

field in which commercial research operates. Production costs in most competitive industries have been reduced to a considerably greater degree than the cost of marketing. This was brought out in a very striking manner in the report of the Congressional Joint Committee of Agricultural Research and of late has been repeatedly emphasized by Secretary of Commerce Herbert Hoover. The field, therefore, for commercial research is broad and the opportunities for benefiting commerce and industry are almost unlimited.

Naturally, in view of the newness of commercial research and the lack of training in the procedure of investigation, much of this work has not been as satisfactory as might be desired. This is only a temporary condition, however, which is rapidly being improved as those engaged in this work gain a greater mastery of the technique of investigation.

ECONOMIC RESEARCH

Since the appointment of Herbert Hoover as Secretary of Commerce, there has been a great development of a still broader type of investigational work which may be termed "economic research." This work has for its purpose not so much the study of the specific problems of any one business, but rather the application of scientific laws and principles to the solution of business problems in general.

Hundreds of agencies are engaged in economic research of this character. They include governmental and state departments and bureaus, educational institutions, and private research agencies of many kinds. The work of the Harvard Graduate School of Business Administration, the Northwestern University School of Commerce, and the National Industrial Conference Board are typical examples of this kind of research. Within these fields thousands are engaged in finding out the facts which govern the relation of business and society, and all of this work depends at every stage on the effective use of investigational procedure.

II

THE INVESTIGATIONAL PROCEDURE

Five steps in the investigational procedure: (1) analyzing the problem; (2) collecting the facts; (3) classifying and tabulating the facts; (4) forming conclusions; (5) establishing the conclusion. Outline of chapter contents with suggestions on how to make the best use of this training.

In solving any problem there are certain steps which must be taken. This is just as true of the simple as it is of the complex problem. The only difference is, that in the simple problem the mind passes over some of the steps so rapidly that their separate significance is not apparent and they seem to be performed simultaneously. On the other hand, in the complex problem not only are the steps apparent, but it is often necessary to subdivide or elaborate them.

In all cases, however, the fundamental steps involved in the investigation of any problem are five in number; as follows:

1. Analyzing the problem in order to find out what is wanted and devising working hypotheses to guide the work of investigation;
2. Collecting the facts bearing on the problem as analyzed;
3. Classifying and tabulating the facts in order to bring out similarities, tendencies, and concomitant variations;
4. Forming conclusions through logical processes of inference and reasoning;
5. Testing and verifying the conclusions.

1. ANALYZING THE PROBLEM

The first step in the study of any problem is a careful analysis, the purpose of which is threefold: (*a*) defining the problem, (*b*) determining the objective, and (*c*) devising

working hypotheses. For example, a large number of motorists have had the disagreeable experience of having their motors "stall," off somewhere in the country far from any garage or service station. Here is a problem to be solved that is somewhat more simple than the usual industrial problem because it involves mechanical elements only, but it is none the less a problem.

The inexperienced driver, recalling things that he has heard, tries this thing or that. Perhaps he strikes the right one and the car starts up again, but more often, after some minutes spent in fruitless fumbling, he is no better off than he was in the beginning.

What does the experienced driver do? First of all he isolates the seat of the trouble—in other words, he "defines the problem." Perhaps he is out of gas or the gas line is clogged. Perhaps the trouble is due to a short-circuit or a broken part. One by one he systematically tries the different possible causes of the trouble until he strikes a probable one. All of this constitutes the pre-analysis. No actual work has been done on the car as yet. It would be only wasted effort to attempt such work before the probable cause of the trouble, or "working hypothesis," has been determined.

Naturally the more thorough the pre-analysis, the quicker one locates the real seat of the trouble and, granted that the adjustment or repair is within the ability of the driver, the succeeding stages of deciding what is to be done and doing it follow logically.

And so it is with any problem—industrial, commercial, or personal. Of course, the character of the problem will inevitably influence the plans for conducting the investigation and the type of information that must be secured. What would be essential for a production study might be only incidental in a market survey, or vice versa.

The clearer the problem is defined, the more apparent the objective, and the more suggestions as to possible angles of approach or working hypotheses, the greater is the possibili-

and allow themselves to be influenced in one direction or another by the opinions and snap judgments of advisers who have, perhaps, an entirely erroneous conception of the issue involved. Instead of analyzing the problem and locating all the activities which affect, and are affected by, its solution, they see it only from what appears to be the principal function involved. Lacking a systematic method of approach, they come to a conclusion which sacrifices more advantages, perhaps, than it conserves."

NEED FOR AN ORDERLY TRAINING FOR RESEARCH MEN

The need for an orderly procedure for training research men is therefore indisputable, and to fill this need, the procedure herein outlined has been organized. Fundamentally, this procedure has been developed from the standpoint of the engineer, for, in the last analysis, investigation is a scientific process. However, in order to reach the thousands engaged in research work who are not engineers, the method of presentation is along practical, rather than technical, lines. The principles described have been tested in every conceivable type of investigation, from the study of the simplest business problems to the most complex industrial audit. In order to demonstrate this universal application, care has been taken to select the illustrations from as wide a range of work as possible.

In addition to being an essential training for the engineer or investigator, the study of this procedure is of great value to the executive, even though he may never have to make an extended investigation. Even the simplest executive decision calls for analysis, gathering of data, and formation of conclusions. When he knows what is involved in these steps and what dangers to avoid, he is better prepared to make profitable decisions.

Thus careful analysis and logical reasoning supplant guesswork and "hunch" in deciding important issues, and

the executive becomes master of his problems instead of letting them master him. Through repeated use, the procedure hereafter described becomes habitual and the ability to form quick decisions is acquired, which combines the natural intuitive judgment of the experienced executive with the logical judgment of the scientist or engineer.

The interview is a useful short-cut for getting information that is too special in character to be published. The investigator has time to acquire only a relatively small percentage of his information through personal observation and experiment. There also may be but little written on the subject, and that little may not be available at the time. In order, therefore, to gather significant information, the investigator must talk with those who possess the knowledge which he needs, and the ability to gather information in this way becomes essential. There is an art to the conduct of an interview, and some practical suggestions for its proper handling are given in Chapter IX that will aid in developing this capacity.

The questionnaire as a medium of collecting the facts is confined largely to those investigations of broader scope where the time element is not preeminent. Its use, however, is increasing rapidly, so that a knowledge of the fundamental principles involved in its successful application is valuable. In Chapter X the basic principles involved in the preparation and utilization of questionnaires are fully discussed.

In any particular type of investigation any one or all of these methods may be used. Each has its own field in which it operates most efficiently. Combined, however, they make it possible to reach every significant fact, if time allows; but in order to utilize these methods successfully one must have the right attitude of mind. Bias and prejudice on the part of the investigator are disastrous. Hence, before taking up the actual procedure of "collecting the facts," the control of prejudice is discussed in Chapter V.

In order fully to utilize the methods subsequently developed, full use should be made of those "aids" described in Chapter VI. Chief, perhaps, of these is a fundamental knowledge of the mechanics of research work, coupled with a serviceable memory and supplemented by the ability to test the value of facts quickly and accurately.

3. CLASSIFYING AND TABULATING THE FACTS

Following or accompanying the collection of the facts come the systematic classification, testing, and tabulation of the data. This classification must be such as to bring out the general tendencies of the facts and either by comparison or by other means to emphasize those particular facts which are necessary for the support of the hypotheses. The testing must be such as to determine truly the value of the facts and their proper relation to the problem, and the tabulation of data such as to present the information obtained in a convincing, easily understood manner.

Almost any one can be trained to gather the facts with a fine degree of accuracy. Quite other qualities are called for in order to utilize properly the information thus secured. Such utilization requires the ability to think clearly and, hence, before the subsequent steps in the investigational procedure are introduced, the nature of thinking is briefly discussed in Chapter XI.

After the facts have been gathered they represent but a miscellaneous mass of data until they have been classified and grouped according to some logical arrangement. The power of discrimination and the detection of identity are the two mental processes upon which reasoning is based. Classification, therefore, calling as it does for the careful observation of similarities and differences and the detection of fundamental bases, operates practically as a preliminary step to the forming of conclusions, although this step actually does not take place until later in the procedure.

Consequently, the laws of definition and classification are fully discussed in Chapter XII, and some helpful rules given which will aid materially in arranging the facts, not only for their most effective use, but also with a view to making it easy for the mind to form logical conclusions from their consideration.

During the process of classification and preliminary to the

ty of hitting the right solution. From the number of possible hypotheses before one for consideration, a large proportion may be quickly dismissed as obviously incorrect. There remain one or a few which are worthy of further consideration, however, and further efforts are devoted to proving or disproving these assumptions and to developing fully the manner of their application to the problem.

Now, if but one hypothesis were developed at a time, it would often be necessary to go back many times and begin the work all over with a fresh assumption. Hence, it is best to organize the procedure for collecting the facts so that the essential ones can be quickly gathered. This makes possible the limiting of further work to those hypotheses that may be regarded as worthy of further consideration.

Although a valuable agent in the preliminary analysis, the formation of hypotheses is not a step confined to this stage of the work. The formation and development of these working assumptions, tentative solutions or principles usually mark all stages of the investigation. As research opens up additional facts, hypotheses must be modified or abandoned for new ones. All of these matters are fully discussed in Chapter IV.

2. COLLECTING THE FACTS

With the situation analyzed, the objective of the investigation determined, and certain assumptions or working hypotheses formulated, the next step in the solution of any problem is the collection of facts to prove or disprove and to develop these assumptions. Take the problem of reducing manufacturing costs. The objective may be that of increasing individual production and the "working hypothesis" or probable solution may be "a production bonus." But are conditions such as to make it possible for the workers consistently to increase their output? Without collecting information on these and other points, any attempt to devise a wage-incentive plan would be folly.

So it is in other fields. What manufacturer can hope successfully to advertise and sell his product if he does not know the facts as to the real field for the product; the character, number, and location of potential users; the buying appeals that interest the market, and so on? All of this information can be secured only through painstaking research.

The importance of gathering the facts being realized, the next step for consideration is the methods employed in collecting them. There are four sources for collecting information on any subject, as brought out in Chapter VI. The primary source is personal observation and experiment. But it is equally important to know the secondary sources of information, which are bibliographical research, interviews, and questionnaires.

The average individual has very limited powers of observation. The investigator must be a close observer, capable of getting at the kernel of the situation and able to dig out the salient points. Cultivation of the power of observation becomes, therefore, of especial importance. Chapter VII includes some helpful suggestions along this line.

It is of prime importance for the investigator to know where to look for information. In books, periodicals, and pamphlets are published valuable material on almost every conceivable subject. Some of this information may be of great value to the investigator and may save him countless hours of original research. Through reading what others have accomplished, he is able to avoid repeating the mistakes that others have made, and can start off with his original work from the point where they have left off. Libraries, both public and private, should be more widely used by business men, as well as engineers and scientists. Full use should be made of the valuable reports published by governmental and other public and private research agencies. A brief summary of the principal sources of published information and how to use them is given in Chapter VIII.

tabulation of such data as lend themselves to that mode of presentation, careful consideration must be given to the testing and interpretation of the facts which have been gathered. Although some of this testing can be done at the time of gathering the facts, in many cases accurate evaluation is possible only through making comparisons with other facts of a similar character gathered from other sources.

In other cases, the investigator will find it necessary to analyze the data more critically, so as to find out their real value and perhaps edit or modify them in certain respects in order that they may be serviceable to him. To help him in determining the accuracy and pertinency of the facts, some important rules for testing and interpretation are discussed fully in Chapter XIII.

Not all the facts gathered by the investigator lend themselves to tabulation or presentation, either in the form of averages or percentages. In many cases, especially in extended investigations, much statistical information is collected, and it is essential, therefore, that the investigator know the fundamental principles of tabulation and statistical methods.

Without going into the science of statistics in any detailed fashion, sufficient basic information is given in Chapter XIV so that the investigator will be able to deal effectively with the usual type of statistical data which will be gathered in commercial and industrial investigations. Practical suggestions are given which will be helpful to him in making the most effective tabulation and presentation of these data.

4. FORMING CONCLUSIONS

The collection of the facts is but a means to an end. The purpose of the investigation is to discover something, and growing directly out of the preceding step comes the formation of conclusions, the working out of a solution to the problem. From the facts, one draws inferences, develops

additional hypotheses, gathers more facts, and continues this process until he has arrived at definite conclusions.

Up to this point the working assumptions have been temporary bridges which have made it possible to cross the stream. Safely across, it becomes possible to reason calmly as to the precise location where it will be best to establish the permanent structure. It is important that this fact be kept in mind at all times, otherwise working assumptions will tend to harden into convictions. Until the conclusion is absolutely established, it is essential to keep the mind open to new ideas and to maintain the ability to see the problem from fresh angles. By so doing, unsuspected facts can be unearthed which otherwise might be overlooked.

5. ESTABLISHING THE CONCLUSION

The formation of a conclusion, development of a solution of the problem, or an explanation of the facts, is essentially a threefold process. The first stage is concerned with the development of suggestions or inferences covering possible solutions, explanations, and so on, as brought out fully in Chapter XV. Then follows a more exact comparison and contrasting of the observed facts through means of inductive reasoning, resulting in the formulation of an hypothesis or probable conclusion. This step is fully discussed in Chapter XVI.

The third step follows immediately, which is that of verifying this hypothesis mainly through the use of deductive reasoning, coupled with the search for other facts, if necessary, to absolutely prove or disprove the conclusion. This step is considered in Chapter XVII. This completes the cycle of thought. If handled correctly in all its phases, and if applied to adequate and correct facts, the conclusion must be correct.

But while the formation of logical conclusions based upon the facts collected may close an investigation of a purely

informative character, in the average industrial investigation, however, a further step is demanded, which is the interpretation of these conclusions and the preparation of recommendations showing what the investigator suggests in order to correct the conditions on account of which the investigation was made. The ability to devise new and improved methods which are practical is an essential characteristic of the real investigator. To do this the investigator must possess a constructive imagination and give constant consideration to the factor of practicability.

This is the scientific method of attacking a problem. It is a procedure which, if applied conscientiously to the solution of all problems, both personal and business, will save disappointment, loss, and regret. It is the same procedure which has brought about the discoveries which have meant so much to our material progress. Chance often steps in and short cuts an investigation, as in the case of the vulcanization of rubber; but usually the solution is worked out through painstaking and laborious running down of every possible hypothesis.

Only when it has become habitual to the user is it most effective. A man should not pause in the process of thought to consider the method of his thinking. But when a problem is complex and many factors are involved, the formal use of this method may be of benefit. The assembling in written form of the constituent questions and their chief factors, with the value and importance of each approximated, should at least clarify the situation and increase the chances of a satisfactory solution.

There is no reason for any mystery to exist in the mind of any one as to "the scientific method." The scientist uses the same thought process as any individual. He observes facts, classifies his observations, makes inferences, and forms conclusions. However, because he has the orderly approach referred to previously, he observes more critically, classifies more accurately, is surer in his judgments, and draws on

wider sources for his inferences. Any one, however, by strengthening himself in these respects, can work scientifically; and it is the aim and purpose of this procedure to furnish the means whereby every one can so strengthen himself.

No matter what may be the nature of the investigation, how extended or limited its scope, the basic procedure thus outlined must be followed. Obviously, in investigating a simple problem some of the points discussed may apparently be omitted, but a careful analysis of the matter will show that in reality every step has been taken in its logical order.

When carried out in this thorough manner, investigation not only gets the real facts and arrives at correct conclusions, but often the by-products of the work are fully as valuable as the conclusion itself. For instance, a well-known office equipment concern was troubled with a large number of complaints regarding its products. An analysis was made of the complaint file and supplementing this a questionnaire was sent out to dealers and customers soliciting kicks and criticisms regarding their product and service.

The replies and the data obtained from the investigation of the complaint file were classified and tabulated. From the material thus presented a veritable mine of information was disclosed which was of valuable service to every phase of the business. For instance, the information showed that in the engineering department certain improvements were desirable in the design of the product. Work was started on this, resulting in the production of improved models that eliminated the trouble that had been encountered before.

The information further brought out the fact that a great deal of the trouble experienced by the customers resulted from improper use of the equipment, faulty installations, and so forth. This led the sales manager to organize a service department composed of several men who were experts in the proper use of their appliances. Whenever a customer was sold appliances, these men were sent to install them and to show the purchaser how to make most effective use

of them. Still other valuable information was disclosed which was of inestimable value in promoting the efficiency of operation and sales in this concern.

Before starting, however, the detailed treatment of each phase of the procedure, it may be desirable to consider what type of individual is required to handle investigational work effectively, and for that reason the next chapter will be devoted to the discussion of the essential qualifications of an investigator or research worker.

III

THE QUALIFICATIONS OF THE INVESTIGATOR

Two broad types of qualifications necessary. Professional qualifications, including: (1) knowledge; (2) experience; (3) special qualifications. Personal qualifications, including: (1) judgment; (2) integrity; (3) poise; (4) vision; (5) perseverance; (6) cooperation; (7) physique. Discussion of these essentials. How to strengthen these qualities.

Considerable uncertainty exists as to the essential qualifications of an investigator. Even among those concerns whose business it is to make investigations, such, for instance, as research agencies, engineering concerns, and the like, but few definite standards have been developed. As a consequence, the selection of staff men is frequently a matter of guesswork, and the training given them is of a rather desultory character.

Even worse conditions are the rule in industrial establishments where investigational work is only incidental. Men are hired or assigned to the work because they have been successful in handling other work, and it is assumed that they will be equally efficient in making investigations. Such is not always the case, for the work of the investigator requires certain very definite qualifications which may not be absolutely essential in other fields of endeavor.

Seeing the need for developing some definite standards in this respect, the writer set out several years ago to analyze a number of individuals who were engaged in engineering and research work. Both the successful and the unsuccessful were considered, since it was felt that from the negative points considerable information of value would be disclosed.

Several hundred such analyses were made, and from these the qualifications discussed hereafter were ascertained and

listed. They were checked back against the different types of research work, and it was found that although there was some variation in the order of their importance, yet there was a decided agreement as to their necessity and relative importance.

As a matter of convenience in utilizing this list for selection or training purposes, the qualifications have been grouped under two divisions:

1. Those which are of a professional character, consisting of the knowledge, experience, and special qualifications requisite for the work in question.
2. Those which are of a personal character, essential for any type of investigational work, since they enable the investigator to make effective use of his knowledge and experience.

Not every one possesses these qualifications in proper proportion. It is a rather common failing for engineers to give undue emphasis to knowledge and experience, and too little to an adequate understanding of human nature. On the other hand, a pleasing personality, although it may gain the good-will and cooperation of all, will nevertheless not insure success if it is not backed up with sound knowledge.

PROFESSIONAL QUALIFICATIONS

Taking up for consideration first those qualifications which are made necessary by the special requirements of the work, it will be found that they fall into three divisions:

1. Knowledge of the basic laws and principles governing the subject in question;
2. Experience in the effective application of that knowledge;
3. Special qualifications made necessary by the nature of the particular work.

1. *Knowledge.* Knowledge implies more than simply a store of information about the subject. It carries with it three definite conceptions:

(*a*) A working knowledge of the subject;
(*b*) Ability to make practical use of the sources of information bearing on the subject;
(*c*) A scientific attitude of mind.

The investigator must know something about this subject, otherwise it is hard to see how he can effectively carry out original research work. But this knowledge need only be as deep as the requirements of the particular work demand. In the research laboratory it may be essential for the investigator to possess an intimate knowledge of chemistry, physics, or mechanics. On the other hand, in a market survey he may need but little technical knowledge—general intelligence and common sense, as a rule, being much more important.

In the case of the industrial engineer, it is not always essential for him to have an intimate knowledge of the methods and processes of the particular industry, although this is desirable. He must possess, however, a broad, fundamental knowledge of the basic laws and principles which govern effective management. If he possesses this knowledge combined with practical experience, judgment, and vision, he will be able to devise ways and means of improving conditions, eliminating waste, reducing costs, and increasing sales or volume of production.

How the investigator acquires this knowledge is not of prime importance. A college education is desirable but not essential, for the man possessing the natural aptitude for investigational work can easily acquire the necessary knowledge through home study. Still, other things being equal, the possession of a college training is of great value, not so much because of the specific knowledge gained but because of the broader view-point which it gives the individual. Some one has very aptly put it, "A college education teaches a man a few things and where to find out the rest."

While the actual possession of an intimate knowledge of the subject may be entirely unnecessary, in all cases it is

essential for the investigator to know where to find out such information as he may need in order to carry out his work effectively. He must know what are the available sources of information, and how to make use of them. It is true that frequently the necessities of the situation do not allow the time for reference to sources of information outside of his own knowledge and experience, but require the formation of a decision based only on the information immediately at hand. Such instances, however, are not frequent, there being, as a rule, sufficient time for looking up essential data on the subject.

It is particularly important for the investigator to have a scientific attitude of mind, and this is very largely developed through his education and training. The scientific attitude enables him to approach a problem entirely without prejudice, intent only on finding out the true facts, with a willingness to accept the truth when found, even though it may be distasteful or not in agreement with his personal opinions.

He must possess not only analytical ability—that is, the power of tearing a proposition down into its vital elements and classifying them properly—but also synthetical ability, which is the capacity to build up from these details a new plan or develop a new idea which will better conditions materially. The investigator who does not possess the scientific attitude of mind, with the capacity to observe closely and think clearly with regard to his observations, can never hope to be a success.

It is fortunate that knowledge is, largely, an acquired qualification. Any one finding himself lacking in a sound understanding of the work which he is investigating, can easily acquire the information he needs through study or actually doing the work. If he does not know exactly where to look for information on a desired subject, he will be helped considerably by a careful study of Chapter VII, in which the different sources of information are classified. Practical

suggestions are given, showing how to make the most effective use of the sources. If he lacks somewhat the proper scientific attitude, this may be corrected by practicing close observation, reading, and meditating on what he reads.

2. *Experience.* The investigator should have some practical experience at the work, whatever it may be. This does not mean that he must be an expert, but it does mean that he should have a practical knowledge of how the work is done; otherwise he cannot determine the proper emphasis to be placed upon the details that he will observe. He will not be able to separate and classify the variables and is very apt to be led astray by unusual conditions.

A young man was employed to make time studies in an eastern manufacturing concern. The management was having considerable labor trouble in the machine-shop, and the new man was sent to take time studies of the work with a view to the establishment of standards and the development of an incentive wage system. Unfortunately, he had neither practical experience at machine-shop work nor the ability to enlist the cooperation of the workers, and every possible obstacle was placed in his way.

After weeks of work, he started to develop standards which were sent to the superintendent for approval. The superintendent was an expert machinist, and as soon as he saw the standards, he realized that something was wrong, for they represented, in most cases, from 15% to 25% more time than he knew an average man needed to do the work. On further checking up, the same situation was found true with regard to the other time studies, and the whole collection was thrown out as worthless.

Had the management selected a man with practical machine-shop experience and instructed him thoroughly in the art of taking time studies, this failure could have been averted. Today, in this concern, tremendous possibilities exist for reducing costs through investigation of the operat-

ing methods, but on account of that unfortunate experience, the management cannot see the value of this work.

In fact, so important is this practical working knowledge of the subject in most instances, that in case of a choice between an alert, practical man who knows the work and an investigator inexperienced in the work, the probabilities are that the judgments and conclusions of the former will be superior to those of the latter, and reached in a fraction of the time.

The degree of importance which is assigned to experience varies with the character of the investigation undertaken. In the case of the industrial engineer it receives major consideration; it being the usual thing to require several years' experience in a number of types of industry in addition to an understanding of the basic principles of management. In many other lines of investigation and research, such a varied experience is not at all necessary, as the work simply requires the ability to observe, analyze, and reason clearly from the facts.

3. *Special Qualifications.* The peculiar requirements of certain classes of investigational work often call for special qualifications on the part of the investigator. For example, in the industrial engineering profession, one large concern lists the following as essential:

(*a*) *Age.* The standard age is from 33 to 40 years. In cases where superior qualifications, such as experience or technical knowledge, and so forth, are possessed, this age limit may be extended at discretion.

(*b*) *Freedom to travel.* Candidates should be either single men, or married men with small families. They must be so situated that they can have no objection to living, for considerable periods of time, in various localities perhaps widely situated.

In order to be able to handle commercial research work effectively, the vice-president of one of the large advertising agencies mentions the following additional qualifications as

desirable: "The research man should have a thorough basic understanding of economics, higher mathematics, and some experience in statistical work."

While there will be perhaps other special qualifications necessary for the effective handling of certain kinds of investigational work, the foregoing represent, perhaps, the most usual additional requirements. In all cases, however, such special qualifications, as a rule, are not as essential as the general qualifications which have already been mentioned and which will be given hereafter. These special qualifications will often be very desirable, but as a rule, where additional requirements of this sort are demanded, the investigator possessing the fundamental qualifications for this work can readily acquire the desired additional qualifications through study and application.

PERSONAL QUALIFICATIONS

Important as are the qualifications of knowledge and experience, these must be ranked as secondary in importance to those qualities which go to make up the personality of the investigator and which control the use which he makes of his knowledge and experience. These personal qualifications may be grouped for discussion under the following heads:

1. Judgment
2. Integrity
3. Poise
4. Vision
5. Perseverance
6. Cooperation
7. Physique

1. *Judgment.* Judgment is the faculty which enables one to profit from his knowledge and experience. It is one of the most valuable qualifications for any line of work, but is especially vital to the investigator, who must be constantly making decisions as to which course of action to follow.

Judgment may, to a considerable degree, be acquired through training and experience, but the capacity for it must be inborn. The ability to form accurate, dependable decisions is one which many men never acquire. Although possessing a thorough knowledge of the subject and an ample experience, they waver from one view-point to another, and find it impossible to reach a decision.

In most cases this inability to form sound judgments is merely the result of mental laziness. If one finds difficulty in reaching decisions, or if he has reason to question the soundness of his judgment, he can easily remedy this condition through training. Habits of accurate observation and logical reasoning from observations, should be cultivated. Prejudice or sentiment should carefully be excluded. In a later section considerable attention will be given to correct processes of reasoning, and many helpful suggestions will be offered that will aid in building up this essential qualification.

2. *Integrity.* The investigator must possess a good reputation among his associates and former employers for integrity and reliability. Honesty, sincerity, and truthfulness comprise qualities without which no one can succeed. At all times the investigator is dealing with causes and effects produced by the operation of natural laws, and he must not allow specious reasoning, however brilliant or clever, to lead him to violate any of these fundamental laws. Facts must be faced; analysis must supplant guesswork; hearsay must give place to absolute knowledge; reason must prevail, and natural law must be obeyed.

A clever lawyer may be able through his eloquence to convince a jury that two and two are five. A journalist may distort the news so as to have it agree with the editorial policy of his paper. Such things are expected, but not so in the case of the engineer or investigator. Juggling of facts or figures is neither expected nor tolerated. If the investigator presents unsound conclusions, or makes unprofitable recom-

mendations, he will inevitably reap the reward of his dishonesty.

The importance of integrity can hardly be overestimated. So essential is it in the field of management and industrial engineering, that one of the leading technical societies, The Taylor Society, publishes the following creed in its bulletin:

A Management Engineer's Creed

The sublimest duty of the engineer is to keep the faith:

The faith of the client that he will not undertake what he knows to be beyond his ability; and that with respect to what he undertakes he will give conscientious service to the limit of his ability;

The faith of his fellow engineers that he will remain true to his science and will magnify and not cheapen it; and that he will base his efforts for public recognition upon ability, scientific attainment and actual performance, and not upon ambiguous self-laudation;

The faith of the community that he will undertake no service inconsistent with the public welfare; and that in service consistent with the public welfare, but in which the interests of groups appear to come in conflict, he will judge carefully and sympathetically the claims of rival interests, and attempt to establish that unity of purpose which promotes the public welfare.

There are many ways in which the engineer or investigator may ruin his reputation for integrity. Out of friendship he may overlook certain facts of vital significance. On the other hand, he may allow dislike to cloud his vision and warp his judgment. Through compensation of some kind or another, he may recommend the purchase of equipment or materials which are not the best for the purpose. Of course, there are cases where a *bona-fide* error has been mistaken for dishonesty. However, the investigator is paid for knowing, and he must be prepared to suffer the consequences if he lets himself be deceived.

Honesty and accuracy of thought are closely associated. The investigator must see things as they are—not as he would like them to be. In describing facts, he must be exact; no rough approximations will do. With infinite patience,

he must seek out the essential facts and classify them correctly so that sound judgments can be formed. Then, having formed his judgment, he must have the courage of his convictions and stick to it until he has been convinced, through logical and not sentimental reasons, that it is not feasible.

What passes for dishonesty, in most cases, is simply allowing prejudice and sentiment to influence the consideration of the observed facts. Even though one may find himself coloring the facts as he observes them with his own interpretations, he should not allow this to discourage him. "Practice makes perfect," so the saying goes, and the very work of investigation, requiring, as it does, accurate observation and correct reasoning, tends to develop honesty in the individual. By exercising control over his prejudices and his emotions, the investigator can prevent these from influencing his observations too greatly and thus fortify his conclusions.

Loyalty is still another manifestation of honesty. It is fidelity to one's duty and to the personalities to whom one is under obligation. Great care must be taken that the virtue of loyalty does not develop into the vice of dishonesty. This often happens through a misplaced sense of loyalty to some individual, which causes one to distort or misrepresent the facts. It is just as essential to avoid this danger as it is to avoid the more direct types of dishonesty. In fact, the former is perhaps more dangerous than the latter because it is so insidious in its operation.

3. *Poise.* Poise is the outward expression of an inward condition of balance between the mental, moral, and physical qualities. It displays itself through the ability to see things in their true proportions, combined with confidence in one's ability to accomplish what is desired. Poise is a valuable qualification in any profession, but it is of especial value to the man who is called upon to investigate or inquire into the true relationship of facts.

One quality which is usually found in the man of poise

is a sense of humor. In difficult situations, and the investigator is constantly running into such situations, the ability to see the humorous side eliminates friction in the same way as does oil in the bearings. When combined with tact and diplomacy, humor constitutes one of the most effective aids in securing the hearty cooperation of others.

The balanced man applies to everything the test of practicability. He has ideals, but does not let them run away with him. He keeps his feet firmly on the ground and knows at all times where his next step will take him. He is essentially a conservative, realizing the necessity for compromise. When he sees it impossible to get what he considers best, he takes the next best thing. He has the courage to accept distasteful conclusions and to alter his plans and opinions when new facts come to light which force such modification. He realizes the limitations of his knowledge and experience, and the uncertainties which surround every problem with which he deals.

This faculty of poise can be cultivated like any other. Experience is the great agent in its development, but while it is the best teacher it is a very expensive one both in time and money. Reading what others have done—especially of their failures—analyzing and meditating on the causes for these failures, and making such experience personal, aids greatly in developing a true sense of proportion, and with it the quality of poise.

4. *Vision.* By vision is meant the ability to form a clear picture, in the imagination, of the results which a certain course of action will produce before that action actually takes place. Nothing is farther from the truth than the belief that the imagination, while of great value to the artist or writer, is a source of danger to the practical man.

On the contrary, it is one of the most valuable faculties he can possess, but it must be the constructive type, based on practical consideration, and not what is called in current speech "dreaming." Constructive imagination enables one

to see a need and the remedy before the need arises. Through the use of this faculty, it becomes possible to forestall difficulties and overcome obstacles before they actually appear. It enables one to visualize the appearance of his completed work in all its details.

The line between the impractical dream and the practical vision is hard, if not impossible, to draw. It is a matter of record how people ridiculed Bell, Morse, Field, and others because their dreams apparently seemed impossible of attainment. In our own generation thousands have been guilty of the same lack of vision with regard to the possibilities of the automobile, the aeroplane, and the radio.

Vision alone will not accomplish anything. The dream remains but a figment of the imagination until technical knowledge and practical experience are brought to bear upon it. Originality and resourcefulness are the direct outgrowth of the practical use of the imagination. When these are combined with organizing ability and initiative, the stage is all set for making the dream a reality.

Vision, or constructive imagination, is a part of intelligence. Every one possesses this faculty in connection with things thoroughly understood. If, therefore, the investigator feels himself to be weak in vision, this may be corrected through obtaining a broader view of the subject. Very helpful will it be to read of the great accomplishments of science. Far more wonderful are the actual accomplishments of science than the strangest imaginings of fiction. Through reading how others have seen the vision, the same ability is acquired.

5. *Perseverance.* The investigator must not be easily discouraged. Only too frequently he has to work under great disadvantages. When assigned a problem, he must keep everlastingly at it until he finds the correct answer. To do this effectively he must have courage of a high order, coupled with the right kind of ambition and a real interest in his work. When the foregoing are coupled with honesty, ex-

pressed both in thought and action, thoroughness results, which insures that all the evidence will be gathered before final judgments or conclusions are formed.

Thomas A. Edison has repeatedly emphasized the importance of possessing the quality of stick-to-itiveness. In a recent interview, among other things, he said:

> Nearly every man who develops a new idea works it up to a point where it looks impossible, and then he gets discouraged. That's not the place to get discouraged, that's the place to get interested. I do not recall a single problem in my life of any sort that I ever started on that I didn't solve, or prove that I couldn't solve. I never let up till I had done everything I could think of no matter how absurd it might seem as a means to the end I was after.
>
> Take the problem of using the best material for phonograph records. We started out using wax. That was too soft. Then we tried every kind of wax that was made, and every possible mixture of wax with hardening substances. We invented new waxes. There was something objectionable about all of them. Then somebody said something about soap. So we tried every kind of soap. That worked better, but it wasn't what we wanted. I had seven men scouring India, China, Africa, everywhere for new vegetable bases for soaps; after five years we got what we wanted and worked out the records that are in use today. They are made of soap too hard to wash with and unlike any other in use, but soap all the same.

While persistent in his search after the facts, the investigator must guard himself against becoming too aggressive and thus arousing hostility. Especially when gathering information from others he must remember that it is his duty to find out what they know about the subject and not to sell them his own ideas and conceptions.

6. *Cooperation.* The investigator must be able to gain and hold the confidence of the workers with whom he will come in contact, as well as the executives with whom he must deal. To do this requires the possession of a number of related faculties which may be grouped, for purposes of discussion, under the heading of cooperation.

One of the most important of these is salesmanship. If

the investigator cannot sell himself and the work he is doing to those with whom he must come in contact, he cannot gain their cooperation, and his work is almost doomed to failure. To sell both himself and his work effectively, he must know how to:

(*a*) Attract the favorable attention of others;
(*b*) Develop their real interest in what he is doing;
(*c*) Arouse their desire to assist him in every way possible;
(*d*) Incite action wherever required.

The better equipped he is to do these things, the more favorable are his chances of success in the work; provided, of course, that he has sufficient knowledge, experience, judgment, and other essential qualifications.

To win cooperation the investigator must be a good mixer. He must be friendly at all times, preserve no animosity, and be cheerful and patient in all his dealings with others. Above all, he must not be a snob or become too much imbued with his own importance. While preserving the dignity of his position, he must be on a friendly footing with every one who can aid or hinder his work in any way, from the office boy to the president.

Very seldom can the investigator count on entire cooperation. Usually he must be prepared to meet veiled, and at times even open, opposition. His strongest weapon in combating this opposition is an obvious attitude of open-mindedness, combined with tact and diplomacy. He must be tolerant, overlooking the petty peculiarities of others, tactfully encouraging them to talk, and guiding the conversation so that they will give him the information he desires.

Above all, however, he must play the game straight. He must not become a tale bearer. It is a sign of weakness on the part of the investigator, if he cannot win the cooperation of all but the most obstinate cases through the power of his own personality without bringing to bear the authority which may be behind him.

Finally, the investigator must have self-control. No mat-

ter how he may be baited by the opposition, he must remember that it takes two to make a quarrel and that the man who keeps his temper has a great point of advantage.

7. *Physique.* Under the heading of Physique is included everything which goes to make up the physical side of the individual. Of these physical qualifications, good health is perhaps the foremost, being an essential for success in almost every field of endeavor. Physical defects, chronic ailments, and bodily disorders quickly affect the mind and interfere with the efficient handling of any work.

To have good health one must not only have formed desirable personal and work habits, but also be free from injurious or destructive habits. In fact, intemperance, gambling, and habits of a like nature, automatically bar a man from consideration by a reputable research organization.

Along with good health and freedom from injurious habits comes the possession of unimpaired physical faculties, especially, good eyesight and hearing. While not entirely indispensable in some instances these are extremely valuable faculties, inasmuch as the investigator must gather a large part of his information through the medium of these sense organs.

The possession of the foregoing physical qualifications will display itself in the appearance, in good bearing, cleanliness, neatness, and good taste in matters of dress and behavior. The investigator who ignores his personal appearance and who hopes, through possession of strong, special qualifications to make up for this, sets up a handicap for himself which makes his work exceedingly difficult. First impressions, while not always lasting, are extremely important, and they are influenced greatly by personal appearance.

HOW TO STRENGTHEN THESE QUALITIES

Such, then, are the qualifications of an investigator. Not every one will possess these qualifications in equal degree.

Some will be strong on certain points and weak on others. In fact, the relative importance of these qualifications will differ somewhat with the character of the investigational work.

This being the case, it is extremely desirable for one to analyze as closely as possible the character of work he is doing and to determine the relative importance of these qualifications. Having done this, the next step is to estimate how closely he approaches the ideal with respect to each of these qualifications. The result will be a self-analysis that will disclose his strong and weak points. It will point out the qualities which need development and can be used as a means of strengthening his abilities and capacity.

In making such an analysis the following self-quiz will be found helpful. The questions listed below will set up clear-cut reactions, and the answers, if honestly and conscientiously made, will give one a reliable estimate of his strong and weak points.

Self-Quiz

1. *Knowledge:*

Do I know how to think clearly?
Am I able to grasp new problems and situations quickly?
Have I formed the habit of analyzing problems and situations?
Do I know the various sources of information bearing on my work?

2. *Experience:*

Do I have a practical understanding of the work?

3. *Special Qualifications:*

Regarding the specific work in question, do I have such special qualifications as are desirable in order to handle it most effectively?

4. *Judgment:*

Do I have the ability to make clear-cut decisions after consideration of the facts?
Are these decisions universally good, or do I frequently make mistakes and errors in judgment?
Do I have the courage to be fair and unprejudiced?
Can I eliminate or control my personal opinions?

Can I judge accurately the probable reaction of others to statements, actions, or conditions?

5. *Integrity:*
   Am I sincere and earnest in my work?
   Am I genuinely interested in carrying what I undertake through to a satisfactory conclusion?

6. *Poise:*
   Can I carry responsibility successfully?
   Can I keep my temper under exasperating circumstances?
   Am I able to see the humor in a situation even when the joke is on me?

7. *Vision:*
   Am I able to see better ways of doing things?
   Can I adopt plans or methods so as to improve conditions, operations, methods, and so forth?
   Am I able to plan ahead and foresee how my plans will work out before actually putting them into operation?
   Am I a self-starter?

8. *Perseverance:*
   Do I have the courage of my convictions?
   Do I have enough enthusiasm to keep on with a job in spite of discouragement and reverses?
   Do I stick to my ideas and plans until I make them work or find out that they are wrong?

9. *Cooperation:*
   Is my personality such as to inspire confidence on the part of those with whom I come in contact?
   Do I get along easily with people?
   Can I "sell" myself or my ideas to others?
   Am I a good listener?
   Am I willing to be shown?
   Can I see the other fellow's view-point?

10. *Physique:*
    Is the condition of my health such that I am able to work regularly and at full speed?
    Does my appearance impress people favorably?
    Do I carry myself well?
    Am I active, energetic, and full of vitality?

This picture of one's self is made still stronger if the Self-

Qualifications	Excep-tional	Good	Fair	Poor
1. *Knowledge.* Consider his understanding of business fundamentals; knowledge of his subject; general intelligence; ability to observe, analyze, and reason correctly; alertness; and so forth.				
2. *Experience.* Consider his skill and practical experience at the same or similar work.				
3. *Special Qualifications.* Consider his possession of such special qualifications as the work in question may require.				
4. *Judgment.* Consider his ability to form accurate decisions promptly and profit from experience.				
5. *Integrity.* Consider his reputation for honesty, sincerity, truthfulness, and loyalty.				
6. *Poise.* Consider his sense of proportion, mental balance, sense of humor, practicability, self-control.				
7. *Vision.* Consider his success in doing things in new and better ways; originality; initiative.				
8. *Perseverance.* Consider his stick-to-it-iveness, industry, ambition, energy, and courage.				
9. *Cooperation.* Consider his success in winning the cooperation of those with whom he comes in contact; his adaptability, open-mindedness, and tact.				
10. *Physique.* Consider his physical capacity for the work, freedom from bad habits, appearance.				

Figure 1: Self-rating chart for engineers and research men.

Rating Chart shown in Figure 1 is used for recording the degree of weakness or strength disclosed by the "self-quiz."

Before using this chart, the brief explanation given in the column headed "Qualifications" should be carefully read. Here are briefly stated the points considered in connection with each qualification. As the latter are taken up, the estimates of one's approach to the ideal should be indicated by making a check-mark in the proper column.

For example, suppose one is rating himself with respect to the first qualification—Knowledge. If he is an authority on the subject, or possesses an unusually intimate knowledge of it, he should make a check in the column headed: "Exceptional." If he possesses good education and training, and can analyze closely and think clearly, he should check "Good." If he is only average in these respects, check "Fair," and if he does not know as much about the subject as he should, is ignorant of how to find out information, or lacks capacity to analyze and reason, check "Poor."

By assigning numerical values to the qualifications and to the degrees in which the estimates are expressed, one can reduce the rating to a total percentage. For example, the writer in evaluating the applicants for industrial engineering work has had occasion to use to advantage the following scale of maximums for each major qualification:

Knowledge	15%	Poise	10%
Experience	15%	Vision	10%
Special qualifications	5%	Perseverance	7½%
Judgment	12½%	Cooperation	10%
Integrity	10%	Physique	5%

Each of the foregoing figures represents the maximum to be assigned to a rating of Exceptional in each case. For the other ratings, lesser figures were selected. For example, in the case of Knowledge, the following scale was used:

Exceptional	15%
Good	12%
Fair	9%
Poor	6%

For other types of investigational work different scales may be used, but in all cases the method of rating is the same. Not only is this an excellent method of checking up one's own qualifications and thus finding out where study and attention are needed, but it is of special value to executives who have occasion to hire men to do research work. By rating the individuals applying for this work according to this chart, they will find it a practical measure of his ability along this line. Thus the mistake is avoided of assigning men to research work who are not adapted by temperament or mentality to handle it effectively.

SUMMARY

Not long ago L. A. Hawkins made some apt comments on the type of men required in research work, in an article entitled "Research and the Modern Industrial Laboratory," published in *Industry Illustrated*, December, 1923:

The successful laboratory is built of men, and true research men, like true poets or true artists, are hard to find. Men with promise must diligently be sought, and as they are found one by one their special aptitudes must be developed and the right problems fitted to these aptitudes.

To an engineer that statement may sound overdrawn. I find few engineers recognize the wide difference between engineering and research, but the difference is very wide. It is very seldom that aptitude for both are found in one man. The mental attitude required is fundamentally different. The engineer is the type that likes to deal with certainties. He likes to utilize known materials, whose properties he knows and has confidence in, and to produce therefrom concrete results in the way of new structures, new devices. He likes to see the tangible result of his labors. The research man is primarily interested in the unknown. He seldom has the patience to carry a new idea through to a finished design. He differs from the engineer as the pioneer differs from those who come after him to develop what he has found. Kipling well expresses that ceaseless urge toward the unknown, in his poem, "The Explorer":

"Till a voice, as loud as Conscience, rang interminable changes
On one everlasting whisper day and night repeated, so:

'Something hidden, go and find it. Go and look behind the ranges.
Something lost behind the ranges. Lost and waiting for you. Go'."

It is this restlessness in the face of the unknown, that trait which Kipling elsewhere characterizes as "insatiable curiosity" which marks the research man, but to be successful he must also have the gift of observing and questioning even the commonplace. Just as to the poet "a primrose by the river's brim" was "something more," so the spreading of oil on a river's surface, which was to others merely a pretty iridescence or an obnoxious fouling of the water, was to Langmuir a method of measuring the exact dimensions of the oil molecule, and distinguishing one oil from another. The research man also needs the *scientific imagination*[1] to construct hypotheses, the *analytical ability* to devise the crucial experiments to test the hypotheses, the *resourcefulness, manipulative skill,* and *persistence* to carry through the experiment, the *perspective* which distinguishes the essential from the non-essential, and the *reasoning* which coordinates individual facts into a principle.

[1]The italics are the author's.

IV

THE PRELIMINARY ANALYSIS

The value of the preliminary analysis of the problem. Phases to be considered. The broad perspective. The real objective. Planning the procedure: (1) The type of investigation; (2) the starting point; (3) the subsequent steps; (4) restrictions on the decision; (5) scheduling time and cost; (6) getting the program in writing; (7) the progress record. Advantages of the preliminary analysis.

No one would consider putting up a building without knowing beforehand the nature of the ground on which it was to be erected, and without detailed data as to all structural features, from foundation to roof. In like manner, before undertaking the actual work of investigation, it is essential to analyze the problem from all sides and to plan as carefully as possible the procedure to be followed in carrying out the work.

By so doing, the investigator avoids running off at a tangent into a collection of facts which have no real bearing on the subject at hand. He makes certain that an adequate collection of vital information will be made, and thus paves the way for practical results. In the development of the plan there are three distinct phases to be considered:

1. The vision of the problem as a whole;
2. The determination of the real objective;
3. The preparation of a tentative plan for carrying out the work.

THE BROAD PERSPECTIVE

Once the detailed work of collecting the facts is begun, it is only too easy to get so close to the details that all idea of perspective is lost. As the old saying goes, "You will not be able to see the forest for the trees." The only remedy, there-

fore, is to get a broad, general view of the problem at the start. Thus a true understanding of the various issues involved is obtained. Resemblances to other work of a similar nature are noted, and valuable ideas will suggest themselves that will aid greatly in developing the plan for attacking the problem.

Considerable caution must be exercised so as to avoid being carried too far afield by one's first impressions. It must be remembered that the general impressions secured from this broad view are simply suggestions which must be tempered with a critical analysis of the immediate problem, and are subject to modification or elimination whenever they do not apply.

THE REAL OBJECTIVE

The next step consists of a careful analysis of the problem for the purpose of disclosing the specific objective and the results which are desired. This objective is the pivot about which all the subsequent work of investigation revolves. Unless it is clearly and definitely determined at the start, waste of time and effort is bound to occur.

The obvious beginning of this analysis is with the definition of the problem. Unless the investigator knows exactly what he wants to find out, or the results which are expected from his work, he is almost sure to expend time and effort without accomplishing anything of real value. Perhaps the most effective way to define a problem is to try to express it in words. Ideas become clear and concrete only when they are expressed.

Many a problem, which in the beginning looms big, shrinks into small dimensions, and often even solves itself, when the various issues are clearly defined. Even when an indirect approach to the problem may seem desirable, the real objective should be clear in mind. For that reason, it is a good rule to begin a preliminary analysis with as clear and definite a statement of the problem as possible.

Frequently, in order to determine the main objective, it

is necessary to split up the apparent problem into minor or related problems. After the subordinate problems have been properly classified, the main problem can be seen in its true proportions. Many of these minor problems may be solved at a glance, and the solution of the major problem itself becomes more simple as these constituent problems are eliminated.

Not only should the investigator have clearly in mind the nature of the problem and the real objective of the work, but he must anticipate as closely as possible the issues which will influence the utilization of his work.

> The important thing is to isolate the issues in the case. To this end an analysis of the arguments shows that they fall into three groups. First, the issues of fact; second, the issues of policy; and third, the issues of theory. The issues of fact are to be settled by investigation, by a cold, unprejudiced analysis of accurate data; the issues of policy are a matter for the individual judgment of each merchant or manufacturer, unless the policy runs counter to public safety, health, morals, or general welfare; the issues of theory are within the province of definition and logic, and demand sound premises.[1]

One prominent engineer, who specializes in garment factory layout, makes use of the following procedure in analyzing a layout problem:

1. He draws up a graphic chart showing all the processes in their order of performance.
2. He determines the kind and extent of departmentalization.
3. He determines the method of getting the batches of work to the operatives at the machines and the method of depositing finished batches of work.
4. He complies a list of all equipment, indicating accurate dimensions.
5. He prepares a working drawing of the factory floor and miniature facsimiles or templates of all equipment.
6. He works out the exact location of all pieces of equipment to be placed and indicates exact location on the floor plan.
7. He decides on such items as lighting fixtures, color of wall paint, motor drives, and so forth.

[1] *Journal of Political Economy*, Vol. XXIV, p. 932.

Of course, the foregoing does more than simply determine the objective. It serves to illustrate the value of having a definite plan of attack, which, after all, is the main purpose of the preliminary analysis.

Summing up the value of clearly determining the objective, it may be stated that:

1. It prevents the investigator from wasting his time in the collection of data having no vital bearing on the problem.
2. It forces his attention on the real issues involved, discloses what must be done, and indicates the direction which his subsequent work must take.

PLANNING THE PROCEDURE

As a result of the preliminary analysis a number of ideas and suggestions will come to mind, which may or may not have a bearing on the problem. The next step is to take these assumptions and make a hasty collection of facts in order to test out their real value. Some, it will be found, are utterly worthless and must be discarded. Others have a very doubtful value. However, there will always be left certain assumptions which are worth considering and which may be used as working hypotheses on which to base the subsequent work.

> Science has derived very little or no benefit from the miscellaneous collecting or grouping of facts without any previous notion of what they are likely to reveal. An investigation is usually made for the purpose of answering a definite question, or of verifying an anticipation. With some such end in view, with some principle by which the classification is guided, the result usually reveals not only what is looked for, but frequently, still more fundamental characteristics; for it is impossible to throw facts in any order which reveals one truth, without dragging others into the light with it.[1]

Ideas or suggestions of possible solutions to the problem or probable conclusions will occur frequently during the carrying out of the work. They should be noted down at

[1]Cramer, Frank, *The Method of Darwin,* a study in scientific method, p. 92.

once while the matter is fresh in mind. If it is not possible at the time to test out their value, there will then be no danger of their being forgotten or overlooked.

In planning the actual procedure to be followed in making an investigation, it will be helpful to give consideration to the following:

1. The determination of the type of investigation to be made;
2. The selection of the place where the work shall be started;
3. The decision as to the logical sequence of the subsequent steps;
4. The consideration of whatever restrictions may be placed on the work;
5. The scheduling of each step as to time and cost;
6. The preparation of a program in writing;
7. The provision of means for checking progress.

1. THE TYPE OF INVESTIGATION

All investigations follow the same procedure as to the main steps. Where they differ is in the extent to which the collection of facts is carried. Some are purely experimental in character and can be carried on in the laboratory or shop. Others are bibliographical and simply call for the finding out and utilization of what has already been discovered by other investigators. Other types of investigation call for an extended inquiry among one's fellow-workers, friends, or colleagues. Still others call for inquiries further afield.

In all cases, the difference is largely in the method used in collecting the facts. With the real objective in mind it will be apparent, in general, along what lines the facts will have to be gathered. This will determine the methods to be used in collecting information, and this in turn will influence greatly the plans made for carrying out the subsequent work.

At this time it is not necessary to go into any great detail in planning how the facts will be gathered, as this is a

step which will be treated at considerable length in later chapters. It is sufficient, therefore, merely to determine the broad lines which the investigation will follow so that the work can be effectively planned.

Another point which may well be considered at this time is how intensive the character of the investigation shall be. Shall it be complete, going into elaborate detail, or shall it be partial, just touching the main points involved? This leads directly into the consideration of the time, money, and personnel available and other matters of policy and procedure which can scarcely be decided upon fully at this time, but which must nevertheless be considered.

2. THE STARTING POINT

On account of its vital influence on subsequent work, the determination of the point where the investigation shall start is perhaps the most important decision which the investigator has to make. A mistake here is frequently fatal, or at least, it brings about added expense and decreases the value of the work.

There are three influences which affect the decision as to the starting point of any investigation. These are:

(*a*) The apparent requirements of the problem itself;
(*b*) The relation of the work to other work which has been, is being, or will be done;
(*c*) The desires and wishes of the personalities involved.

These three considerations are present in every problem, though, of course, in varying degrees, and care must be taken to give each its proper share of attention. Experience is the best guide, and that is why on important work it receives such a high rating.

But experience, while of great value, is not absolutely indispensable. In fact, too much experience is frequently harmful, especially when this has been along a special line. When this is the case the investigator is apt to form a set

method of attack which he will attempt to apply to every problem which he encounters. A common example is that of the systematizer who seeks to install the same methods and forms in every concern.

In case of choice between an inexperienced man who gives careful and thoughtful consideration to the three controlling elements, and an experienced one who has become prejudiced in favor of certain set methods, the former will be more apt to accomplish beneficial results than the latter.

Essentially there are only four ways to start the investigation of any problem; one may start with the study of such phases of the subject as:

(1) Logically come first;
(2) Indicate the greatest opportunity for getting results;
(3) Have the most beneficial influence on the work as a whole;
(4) Policy or other plans indicate as desirable.

(1) *The Logical Beginning.* If there were no other considerations than the immediate problem itself, and if there were no personalities to interfere in any way with the handling of the work, it would be a foregone conclusion that the logical beginning is the place to start. In fact, the same is true even when these other considerations are present but are manifestly subordinate to the necessity for following a strictly logical procedure or when the problem is of such a nature that it must be considered as a unit. Laboratory research and time-study work constitute outstanding examples of this method of attack; other cases in point are investigations of operations which follow a definite sequence, each element being dependent on the preceding element and controlling the succeeding one.

In the case of the ordinary business problem, however, it is usually impossible to consider it separately from other issues or from the personalities concerned. Sometimes these other considerations will join with the logic of the situation, in influencing decision as to the place to start. In fact, it is very seldom that a problem is so simple that but one consideration influences the decision.

But, while it may be found advisable to begin the investigation at some place other than the logical starting point, one must not lose track of the logical sequence. The work must be so planned that no matter where the start is made one can come back and pick up the points which should have attention, so that in the end he will have made a complete study of the subject even though it may not have been made in the most logical order.

(2) *Hitting the High Spots.* In practically every investigation there is one place where the greatest opportunity exists for producing immediate results. The selection of such places for beginning the work is called "hitting the high spots." This phase has acquired an unsavory reputation because of "the stunt" performances which characterized the work of many so-called "efficiency engineers," but in itself there is nothing wrong with this method of attack, provided the subsequent work of the investigation is properly coordinated. If this is not done, the work will assume an uneven appearance, and because of its unbalanced development, failure is apt to result.

This point receives greatest consideration when an outside organization is doing work for a client. It is obvious that the one for whom the investigation is being made is anxious to see results accruing at an early date. In fact, if these are not rapidly forthcoming, he is very apt to get discouraged, and refuse to continue the work. For that reason, other things being equal, it is a wise plan to select for the starting place some phase of the work which affords the greatest opportunity for showing profitable results. In that way the client will be sold on the value of the work, and even greater cooperation will be given by him and his organization in carrying out subsequent recommendations.

On the contrary, on investigational work within the organization, the necessity for selling the work itself does not usually exist. While the value of this point because of its psychological effect must always be considered, it can be

kept in the background, greater emphasis being given to the logical beginning or to the desires and wishes of the personalities in charge.

(3) *The Relation to Other Work.* No business problem stands absolutely isolated. It frequently happens that because of its relation to other work it may be advisable to begin at a point which would not be desirable were the problem, itself, alone considered. For instance, in making a preliminary survey of a certain industry the engineers were agreed that the logical place to begin their work was in the factory. However, the accounting system of this concern was in such poor shape that the engineers realized that the savings which they might effect would not be properly reflected in the accounting records.

In this instance, therefore, they decided to begin their work with the installation of a simple cost system which would furnish accurate information regarding the status and cost of the work. When they, therefore, began real betterment work in the factory they were able to show the exact savings and benefits secured which otherwise would not have been apparent.

In many kinds of work, also, there is one phase which occupies a position of special prominence, if not control, over the other phases of the work. When such is the case it is frequently advisable to start at this point, even though it may not be the most logical starting point or likely to produce the most immediate or profitable results. An example of this is the well-known "neck of the bottle." Such a condition often affects seriously a number of other related factors of any problem, and consequently its elimination will have a beneficial effect on the work as a whole.

(4) *Expediency.* Wherever the human element enters into consideration, and this is true in practically every investigation, the desires and wishes of the personalities involved are bound to exert a considerable influence. It is quite true that this should not be the case, but as long as

human nature remains as it is, this fact must be recognized.

No rules can be laid down to deal with such a situation. However, if tact and diplomacy are used and sound arguments presented to show the advisability of starting elsewhere, it is usually possible to get around this hazard. In many other cases it is frequently good policy to acquiesce to the wishes of the person in charge or vitally interested. At the same time, however, as has been stated before, the subsequent work must be so arranged that the thread can be picked up as quickly as possible and the work carried through, thereafter, in its proper sequence.

An industrial engineer was engaged by an old, established concern to install new and improved methods in its factory. In making his preliminary survey he divided the problem into five divisions, corresponding to the five departments of the factory: the foundry, the forge shop, the machine shop, the assembly department, and the office.

As to each of these departments, he took especial care to make observations regarding:

(*a*) The working conditions in the department;
(*b*) The general methods in use;
(*c*) The equipment and its layout;
(*d*) The personnel and the quality of supervision.

Following this plan his preliminary survey showed the following outstanding facts:

As to the Foundry:

1. Working conditions—Fair; lighting poor; ventilation inadequate; workers had to carry ladles long distances.
2. Methods—Antiquated; patterns and castings lying scattered here and there; no aisle or storage spaces.
3. Equipment—Largely out of date; no molding machines; one small crane with limited radius; patterns old and in bad condition, often making it necessary for molder to stop work to repair.
4. Personnel—Average, but no display of interest, partly the result of poor facilities and partly due to the evident feeling of the management that the foundry was a necessary evil; wages on day-work basis.

As to the Forge Shop:

1. Working conditions—Fair; lighting and ventilation good.
2. Methods—Poor; furnaces only half-filled with bars. Excessive amount of time consumed in waiting for heats.
3. Equipment—Excellent; modern-type oil-burning furnaces and forging machines, but layout poor.
4. Personnel—Fair; a "go as you please" attitude; considerable conversation between heaters and helpers; wages partly on piece-work and partly on day-work basis, but real incentive lacking.

As to the Machine Shop:

1. Working conditions—Good; obviously the pet department as far as management is concerned.
2. Methods—Not so good; equipment idle a considerable part of the time; machinists grind own tools, go for stock and take away finished parts from the machines; tools and unfinished parts lie around wherever space is available; excessive handling of materials and parts.
3. Equipment—Machine fairly modern; old-style trucks used; many belts too loose, and some pulleys out of alignment.
4. Personnel—Fair; foreman obviously of high caliber, but not allowed free hand; discipline not so good; works manager was formerly foreman of this department, and deals personally with many of the workers instead of through foreman; wages mostly day-work, but some piece-work.

As to the Assembly Department:

1. Working conditions—Good.
2. Methods—Progressive assembly not in use; frequent interference with volume of production due to employees being absent or leaving.
3. Equipment—Work benches not designed especially for the work; chairs too high for some employees; too low for others; layout not in accordance with flow of work.
4. Personnel—Ordinary. Wages on day-work basis exclusively.

As to the Office:

1. Working conditions—Fair; lighting bad in afternoons.
2. Methods—Seem adequate; no trouble experienced.
3. Equipment—Old but serviceable; layout poor.
4. Personnel—Average.

General:

No places set aside for storage of materials and parts, except for finished product.

Inspection left to control of foremen of different departments.

No centralized planning. Orders worked on according to the immediate demands of the moment, or the wishes of the foremen.

When the engineer came to plan his program for carrying out the work for which he had been engaged, a study of his preliminary observations showed him clearly that there were opportunities for bettering conditions in every department. The question then arose "which one to select as the starting point." He took up for consideration, first, the foundry, which, being the starting department, was the logical point of attack. It was apparent, however, that though this was true, the work which would have to be done there would require considerable expenditure of money in equipment and improvement of conditions before any tangible results would show.

On the other hand, it was obvious that the works manager preferred that the start be made with the forge shop. Some time previous he had recommended the purchase of considerable new equipment in that department, but so far it had failed to produce any reduction in departmental costs. He therefore felt that this failure was a distinct reflection on him and was anxious to have that department put on a more profitable basis.

The machine shop, however, inasmuch as some work was performed there on almost every item of product, represented a place where improvements of conditions would exert a most beneficial effect on the concern as a whole. Not only that, but the engineer himself, being experienced in machine-shop work, felt a natural preference for starting there.

However, the assembly department offered perhaps the most fruitful field for work. It was in many respects the "neck of the bottle," and this was occasioned by the lack of

progressive assembly methods which, he felt, could be installed there quickly, thus producing immediate profits.

As for the office, since it was neither in a strategic position nor offered any particular inducements for attention, he felt that it could be left out of consideration for the time being, with the mental reservation to investigate conditions there more thoroughly after he had organized the work in the other departments.

This analysis narrowed down the decision as to the starting point to a choice between the forge shop, the machine shop, and the assembly department, since the foundry, though the logical starting point, did not in this instance constitute a profitable place to begin the work.

After giving the matter considerable thought he decided that it would probably be most expedient for him, in this instance, to begin work with the forge shop, in view of the desire of the works manager, and, having made a good start, then take up the assembly department, the machine shop, and the foundry in that order.

As it turned out, a more thorough study of the forge shop showed that very considerable improvements could be effected with but little necessity for expense, and he was able to show such immediate profits from his work that his subsequent program for investigation went through exactly as he had planned it.

3. THE SUBSEQUENT STEPS

After the starting point has been determined, the hardest part of the preliminary planning is done, for if the decision in this respect has been wise it is usually possible to line up the subsequent work in logical order.

The main point about the planning of the later steps is to see that there is proper coordination with the main objective. An investigation is like a mosaic. It is complete only when every section is in its proper place. Investigation work, however interesting or desirable, should not be included in the

program unless it contributes directly to the success of the plan as a whole. Such work can profitably be kept until a later date and then taken up entirely on its own merits.

For example, in studying the methods in the shipping department of a large mail-order house, it was found that by rearranging the conveyers so as to provide for a preliminary sorting of parcels, a saving of two minutes could be effected on the handling of each order. A further saving might still be secured through the design of a special machine for handling part of this sorting mechanically. In view of the immediate requirements of the problem, this further investigation was postponed until a later date, and the rearrangement previously mentioned was put into immediate effect. Later the investigator returned to this problem and succeeded, after several months of study and experiment, in solving the problem of mechanical sorting. Had he delayed the installation of his improved layout until this subordinate problem had been solved, the concern would have lost many thousands of dollars in possible savings. Not only that, but it would not have been able to secure the immediate increase in the capacity of the department, which had been one of the main reasons for making the investigation in the first place.

4. RESTRICTIONS ON THE DECISION

From the foregoing discussion and examples, it is apparent that there are many influences which modify or restrict the direction taken by any investigation. Many of these restrictions are peculiar to the problem in question, so that it is difficult, if not impossible, to lay down any general rules for handling them.

If, therefore, one keeps his eyes wide open as he carries out his work, he will become aware of these modifying influences as they show themselves. With the requirements of the problem in mind, he will then have to bring to bear his best judgment, vision, and tact, in order to control those

influences, so that there will be no interference with the effective conduct of his work.

5. SCHEDULING TIME AND COST

Scheduling is just as applicable to investigational work as to other activities. The length of time which it should take to carry out properly each step of the investigation should be carefully estimated. To be sure, this estimate is very likely to be insufficient or excessive in places, but notwithstanding this fact, it represents a mark for the investigator to aim at, and this amply justifies its existence.

At the same time, a cost estimate should be made, showing what will be the probable cost to complete each step. This gives an opportunity to pick out certain work requiring an undue expenditure in proportion to probable results, and makes possible a postponement of that work until a more propitious time. An example in point is that of the foundry work just mentioned.

In preparing such estimates, the inexperienced investigator is very much at a loss, and, in fact, is quite incapable of making anything more than a guess. As he gains greater experience, he acquires the ability to estimate pretty closely how long it is going to take and how much it is going to cost to accomplish certain results.

In preparing this estimate, he must be careful not to be unduly optimistic. Above all, he must avoid promising too much at the start. It is far better to make a few promises and keep them, than to make many promises and, while keeping the majority, fail in a number of instances. In judging one's work, others will be more apt to remember the failures than the successes, however numerous the latter may be.

6. GETTING THE PROGRAM IN WRITING

The preliminary analysis now being finished, all that remains is to set it in writing, so that the plan for carrying

out the work will become something definite—a target in other words, to shoot at. How detailed this written program will be, is determined entirely by the problem itself. For a simple investigation, it is sufficient to make a brief statement showing the aim, the proposed steps, the duration, expense, and the probable results.

On the other hand, in a larger problem where considerable expenditure is involved, such as in a market survey, a rather complete preliminary report may be demanded, showing not only the foregoing basic facts, but also considerable dependent information. This gives those in authority an opportunity to form a sound conclusion as to whether the work as planned should be carried out in full, in part, or not at all.

No rules can be laid down for determining in how much detail it will be necessary to make this written program. The investigator must be guided entirely by his judgment as to the demands of the particular case. In general, however, while planning in considerable detail is necessary for his own benefit, it is advisable to avoid announcing details until the proper time. Conditions are apt to come up which have not been anticipated, but which will modify the direction of the subsequent work. When the details have not been broadcast, the fact of such deviation from the preliminary plan does not become generally known, and thus unfavorable criticism is avoided.

Investigational work is educational in character. Now, it is a fundamental principle of pedagogy to "teach only one thing at a time." So in carrying out the program, do not attempt to put it over completely at one time. Take up each step in its proper place and demonstrate its practicability. Then introduce the next step, and so on, until the complete plan has been covered.

7. THE PROGRESS RECORD

The maintenance of a daily record showing what is being done and how this compares with what was expected is just

as necessary in the investigation as are output records in the shop. Such a record accomplishes two important things:

(*a*) It provides a permanent written record showing actual accomplishment;

(*b*) It furnishes the basis for measuring accurately the effectiveness of the work.

From the standpoint of accuracy the progress record can fully justify itself. But it has an even greater value when, for any reason, it is necessary to have a man finish up a job started by some one else. Without such a record, it would be possible for him to know only in a general way what his predecessor had done and he would of necessity repeat considerable work. However, when a daily progress record has been kept, the new man is enabled to begin at the exact point where the former left off, and thus much time is saved.

A good illustration of the value of such records may be taken from the experience of a nationally known institution. A prominent research man was engaged to make certain investigations, which necessitated his visiting various plants in the United States and Canada, during a period of approximately six months. Knowing his subject thoroughly, he contented himself merely with taking but a few notes in longhand, trusting largely to his memory to bridge over the gaps when he should be called upon to write up his data.

Three days after his return from this trip, and before he had a chance to do any more than start writing up his report, he was taken seriously ill and died within a few days. All that his employer had to show for the expenditure of thousands of dollars and six months' time, was a few hastily scribbled longhand notes, most of which were scarcely readable. Had the investigator been required to send in a full typewritten report of each visit, while the matter was fresh in his mind, together with such data as he obtained, this waste would have been avoided.

Another valuable feature of the progress record is the incentive which it gives the investigator to get results

promptly. Rather than report failures or take too long in accomplishing certain parts of the work, he will redouble his efforts. Thus the preliminary plan becomes a true schedule, and the probabilities of gaining practical results are increased.

In addition, the written record shows plainly how effective the work of the investigator is, and in case of the failure of the investigation it indicates clearly whether the investigator himself was incompetent, or whether causes beyond his control had intervened. The progress record, therefore, furnishes the only true basis for judging the real value of investigational work.

SUMMARY

Summarizing the points brought out in this chapter, it may be said that preliminary planning as to the scope and procedure of the investigation accomplishes the following definite benefits:

1. It furnishes a broad general view of the problem;
2. It enables the real objective to be determined;
3. It indicates the steps necessary to obtain that objective and their sequence;
4. It permits the preparation of a reliable estimate showing the probable cost in time and money;
5. It furnishes a definite standard for the guidance of the investigator and means of measuring his accomplishment.

V

THE PROPER MENTAL ATTITUDE

Prejudice and its dangers. Types of prejudice. Personal prejudice: (1) temperamental weaknesses; (2) overactive imagination; (3) giving way to emotions. Derived prejudices: (1) improper training; (2) influence of custom; (3) influence of authority. How prejudice shows itself with helpful suggestions for eliminating or controlling its influence.

It has been said that the beginning of research is an attitude of mind; certain it is that the investigator's attitude of mind influences, to a very large extent, the direction which his efforts will take and the results which will be secured. Before taking up, therefore, the consideration of the various methods of collecting the facts, it will be well to devote some attention to the attitude of the investigator, for no matter how he may proceed to gather information, his mental attitude will largely determine the results he will obtain.

Naturally, he will carry over from previous experience a considerable array of opinions, and these are bound to influence him more or less in planning and carrying on his work. Some of these opinions may have been formed through logical processes of reasoning; others have been acquired through various channels. All represent varying degrees of truth and pertinence to the subject and when properly used are of great value.

In starting out on any investigation it is well to take an inventory of such opinions as bear on the subject. The value of this is twofold. In the first place, it gives the investigator the benefit of certain working hypotheses that can be used (as has been seen) in working out the tentative plan for carrying on the work. In the second place, this listing, if conscientiously done, will prevent his carrying over into the investigation any inaccurate opinions formed in the past,

thus avoiding unnecessary repetition of work, while insuring that those opinions which are pertinent will be properly utilized.

But when the investigator gets down to the actual collection of data, he must assume an open attitude of mind. While realizing the value of his opinions he must not allow prejudice, bias, or vanity to assign undue significance to them. He must bear in mind at all times that it is his duty to seek the facts wherever they may be found and to record accurately what he finds, no matter what may be his opinion.

Naturally, he cannot fulfil his obligation if he allows preconceived notions to blind his eyes or warp his judgment. It is perhaps too much to expect any individual to be absolutely free from bias or prejudice. Every one is partial to his own opinions. It is, however, demanded that the investigator control his prejudices, forcing himself to keep his mind open and receptive to the truth, otherwise he will fail utterly in whatever investigational work he may undertake.

In order that prejudice may be recognized and properly controlled, some of its most common forms will now be briefly described. It will be shown just how they arise and how they can be eliminated or controlled. Prejudices are of two types: "personal," arising from causes originating in one's own personality; and "derived," arising from contact with others.

A. Personal Prejudices

Personal prejudices will, first of all, be considered because they are very closely related to life-long habits of thought and action; and because they cannot always be recognized, they are insidious in their influence and dangerous in their action. Personal prejudices may be roughly divided into three classes, in accordance as they are caused by:

1. Temperamental weaknesses;
2. Overactive imagination;
3. Giving way to emotions.

1. PREJUDICE ARISING FROM TEMPERAMENTAL WEAKNESSES

Every individual is different; each has his own physical and mental limitations and these often interfere seriously in a search after the facts. Temperamental weaknesses are particularly dangerous because they are usually of long standing and have become almost a part of the individual. This makes them difficult to eliminate entirely, but through determined effort they may be brought under control. Some of the most common temperamental weaknesses are the following:

(*a*) *Gullibility or overcredulity*—an inclination to accept mere statements of others when these are made with a show of authority or assurance, but without adequate proof. In investigating any problem, individuals will be found who "know just what is wrong and can tell you exactly what to do to remedy the condition." To back up this assertion they are often able to offer plausible ideas, which, if taken at their face value, lead the unwary astray.

While it has been emphasized repeatedly that the investigator must have an open mind, this does not mean that he is to accept as facts everything that he is told. He must constantly weigh and measure, and must not be too easily influenced by others as to the weight which he gives to the facts observed.

He must be able to see the facts at all times in their true significance, and record them in the same manner as the sensitive plate of a camera. Also, regarding suggestions and ideas which are passed on to him by others, he must be open to receive them, but at the same time he must examine each impartially and accept only those which have a real bearing.

If one is inclined to accept the statements of others too readily, he can overcome this by adopting a questioning attitude at all times. He should examine closely all the facts which come under his observation, weighing and judging them all in the light of his own experience and other facts bearing on the subject, before accepting them as true.

(*b*) *A skeptical or negative attitude,* which in its least developed form consists of demanding an undue amount of proof before accepting certain facts.

This type of weakness is the opposite of the one previously mentioned. Because of this negative attitude, the mind, instead of being open to the truth, is closed tight against any ideas or suggestions from others. Overcaution is sometimes the cause of this condition. Personal vanity is frequently a compelling motive, but often this weakness can be traced to mere stubbornness.

It is entirely proper for the investigator to be "from Missouri," but he must not let this attitude interfere with his recognition of the truth. This skeptical attitude, carried to an extreme, becomes a negative attitude, which refuses to accept certain facts even when good evidence can be adduced in their support.

The story is told that when George Westinghouse interviewed Commodore Vanderbilt and explained his air-brake, Vanderbilt is said to have replied, "If I understand you, young man, you propose to stop a train with wind; I have no time to listen to such nonsense." Yet, in a few years this invention was adopted on Vanderbilt's own lines.

To a modified degree, a skeptical attitude is often advisable, and may not be disastrous when kept under control, but it is certain that no one with a negative attitude is qualified to do investigational work of any sort, or, in fact, to hold any executive position where important decisions must be made.

If one is unduly skeptical or has a negative tendency, he can overcome this weakness by adopting an attitude of tolerance. Both the skeptical and the negative tendencies are rendered difficult to overcome because of their very character. Where the overcredulous person is open to suggestions that he may be too responsive, the overskeptical person will not be receptive to any suggestion that he is anything but fair and open-minded. The jolts of experience, alone, seem to bring him out of this condition.

(*c*) *An inclination to be hasty in the formation of opinions,* deciding too quickly at times, and at other times with too great a degree of positiveness. This inclination grows directly out of a lack of balance, and the inability to suspend the judgment until all the evidence has been gathered. There is a clear distinction between "quick" and "hasty" decisions. The former comes by reason of rapid analysis and synthesis of the facts. The latter is guesswork without proper analysis and consideration of the problem.

Closely associated to hasty decisions is the tendency to vacillate from one opinion to another, due to a lack of firmness. Needless to say, the possession of any of these weaknesses will make it difficult for the investigator to get any real results.

If one is inclined to be hasty in forming opinions, he can readily overcome that weakness by deliberately postponing the formation of a judgment until he has had time to examine the subject from all angles. The rule which many people have of "sleeping on a proposition" is a good one to follow in deciding matters of importance. It furnishes an opportunity for the introduction of other evidence. It makes possible careful examination of the evidence when the stress or emotion is lessened or removed, and thus enables one to draw a more accurate conclusion.

Another valuable aid in correcting this tendency is to form the habit of listing the arguments pro and con. Through this means the preponderance of evidence is clearly shown, and hasty judgments avoided.

(*d*) *A radical tendency,* which is shown by a liking for those things which are new or which are different. This is a very serious error into which many brilliant research men have fallen. Partially it is due to a lack of balance, but mainly to a lack of the instinct of practicability. It is just as bad to place undue emphasis on the new as it is to be ultra-conservative and refuse to admit a new thing simply because it is new.

The investigator must be somewhat of a radical in tendency, in that he is constantly looking for new and improved ways of doing things. This tendency becomes a weakness only when it is carried to excess or is not tempered with common sense. By subjecting every new idea to the test of practicability, this temperamental weakness can be absolutely controlled. A very good rule to follow is expressed in the old proverb:

> Be not the first by whom the new is tried,
> Nor yet the last to cast the old aside.

2. PREJUDICE ARISING FROM AN OVERACTIVE IMAGINATION

The picture is sometimes drawn of a scientist, engineer, or business man as being a drab individual, devoid of imagination. The truth is quite the contrary. Any man to be successful in any business must possess a strong constructive imagination. The business man who plans his activities for the coming year must be able to imagine what, in general, will be business conditions during that period and how they will affect his business. In fact, without some power of imagination, it will be impossible for him to foresee coming events and properly prepare to meet them or to anticipate results which will occur from the adoption of certain plans or policies.

Back of every great invention and every new idea is the constructive imagination of some investigator, whether he be engaged in the realm of pure science or applied science, which is only another name for business. Realizing, then, its power and usefulness, it is necessary at the same time to set up such controls so as to make possible its most effective use.

During the collection of facts one must be on his guard at all times against allowing his imagination to color the facts in any way. If he has a tendency to be overimaginative, this can best be corrected through giving close attention to detail and relationship. Emphasis upon accuracy of observa-

tion and the avoidance of reflecting on the facts themselves while collecting them will aid in insuring that the information secured will not be colored by the fancy.

When reasoning with regard to the facts, a further control can be established over the use of the imagination by constantly subjecting new ideas and suggestions to the tests of practicability. Some of the most useful of these tests will be given in the subsequent chapters. If the investigator consciously keeps these tests of accuracy and practicability in mind constantly throughout his investigation, he can practically eliminate this type of prejudice from his work.

Such is the direct way in which the imagination enters into the conduct of an investigation in a harmful way. But there is an indirect way in which this type of prejudice frequently shows itself. This consists of reading into certain statements or into certain verbal expressions meanings which the authors have not intended.

Although closely related to deliberate falsification, this is frequently done so unconsciously that the individual does not realize what he is doing. Through constant reiteration, even the most palpable falsehood becomes so very real that it seems the truth. The control or elimination of this weakness is thus made difficult. It is only through cultivation of sincerity and a clear determination to record the facts as they really are that this tendency can be controlled at all.

3. PREJUDICE ARISING FROM GIVING WAY TO ONE'S FEELINGS

Sentiment is a very good thing in its place, but it has no place in an investigation. After the facts are all collected and logical conclusions reached, there may be a place for sentiment in the utilization of these conclusions. Investigation is a scientific, not an emotional, process. If, therefore, the results are to have any value, personal feelings and viewpoints must be entirely eliminated.

The investigator, while at the same time being an actor in the drama, must be able to put himself in the shoes of a

spectator and view the scene through his eyes. No one is entirely immune from this sort of prejudice, and the extent of its influence is hard to determine. It is natural for the individual to be prejudiced in favor of certain ideas or suggestions of his own creation, and it is really impossible to expect him to be able to assign them their true value. This can be done only by some one else.

It is natural for the individual to have greater confidence in his own friends than in strangers. The preference given by many employers to graduates from their alma mater, members of the same church, or lodge, and the other manifestations of this type of prejudice which display themselves every day are only to be expected. Rather than try to eliminate them entirely, the best that can be done is to avoid their abuse, through conscious insistence on fair play and the square deal.

Through use of the merit test and a determination to abide by its decision, regardless of how it affects the personal preferences, the investigator is able to keep this prejudice within reasonable bounds. In fairness both to himself and to the work which he is doing, he must know the true relation of the subjects being considered.

B. Derived Prejudices

From the foregoing discussion the nature and characteristics of personal prejudice have been clearly shown. But these are not the only kinds of prejudice. There are others which, though not so direct in their influence, yet are dangerous when not recognized and properly controlled.

These prejudices differ from the personal in that they are derived from one's contact with others, and they arise in three ways:

1. From improper training;
2. From the influences of custom;
3. From the influences of authority.

A very frequent type of prejudice is that which has been

developed through wrong teaching in early life. Certain wrong habits may be formed which are very difficult to eradicate later in life. Even when the habits themselves are not in any way wrong, their operation has a tendency often to cause inaccurate observations, or results in the formation of wrong conclusions. We have a tendency to see things the way in which we expect to see them, or have been in the habit of seeing from times past.

The influence of custom is sometimes so powerful that it overcomes common sense. This is frequently found in business in the attitude of doing what the other fellow does. It is prejudice of this sort which leads one into a rut, and hinders his own personal progress as well as prevents him from obtaining the true facts in any investigation which he undertakes.

The influence of authority is closely related to that of custom, but is even stronger. It is this prejudice which leads one to accept the conclusions of others without definite proof. Of course, there are times when proof cannot be easily expected and when it is advisable to accept a statement from authority. In other words, while statements of authority must be admitted as part of the evidence collected, they must not be allowed to influence the direction of the investigation when other facts uncovered point to a different conclusion.

In general, prejudice being aroused from a bias or one-sided view-point can be most easily overcome by a conscious effort to see both sides of the proposition. Constant cultivation of an attitude of tolerance will be effective in controlling if not eliminating all types of prejudice.

A very helpful view-point to adopt is to consider every investigation as a new piece of work and attack it with a fresh point of view. Business has too long been hampered by tradition. Experience, while of value as a guide, must not be relied upon to the exclusion of initiative.

The investigator must be on his guard against prejudice at every stage of his work. While it is highly essential that

he start off with an open mind and a neutral view-point, it is even more necessary that this attitude be preserved throughout the gathering of information and the drawing of inferences from the data collected. Otherwise, he will be led astray to form inaccurate conclusions.

SUMMARY

To carry on effective investigational work, or, to be able to direct profitably the operations of any business, one must be able to control, if not entirely eliminate, prejudice from interfering with the collection of facts and their proper interpretation.

This control can be effected through keeping in mind at all times the following simple rules:

1. Cultivate an attitude of tolerance, and endeavor to keep an open mind, receptive to the truth.
2. Be honest with yourself.
3. Develop your powers of analysis and view the evidence from all sides.
4. Suspend your judgment until you have gathered all of the essential facts and analyzed them closely.

VI

METHODS OF COLLECTING THE FACTS

Methods of collecting the facts: (1) through personal observation and experiment; (2) through bibliographical research; (3) through interviews; (4) through questionnaires. Broad or intensive surveys. Aids in utilizing these methods. The mechanics of research work. Selecting the proper units of measurement. Taking notes effectively. The value of a serviceable memory. Simple rules for training the memory. Testing the facts.

From every standpoint, collecting the facts, the second main division of the investigational procedure, constitutes a step of the utmost importance. Indeed, in many kinds of investigations, especially those of an informative character, it is frequently the most important division of the work.

In every investigation, however, gathering the facts occupies a strategic position, as every subsequent step is dependent upon the extent and accuracy of the data uncovered. This strategic position is brought about, first, because it is only through this means that the raw material is secured from which, through processes of analysis and synthesis, final judgments or conclusions are formed.

In the second place, the carrying on of this step calls for the expenditure of considerable time and money, which expenditure often is greater than in any other step and often more than for all the others combined. Great opportunities exist, therefore, for waste and inefficiency. Hence the necessity not only for carefully planning, as brought out in Chapter IV, but also for a thorough understanding of the various ways in which the facts may be gathered.

METHODS OF COLLECTING THE FACTS

It will be recalled that in Chapter IV—The Preliminary Analysis—mention was made of the different methods of

gathering the facts, but at that time no further discussion of these methods was advisable—only sufficient to insure that proper consideration would be given to this subject in developing the tentative plan for carrying out the work.

Since the method of conducting the investigation in a large measure coincides with the method of getting the facts, it becomes necessary at this time to take up and discuss fully the different means used in collecting data on any subject.

All methods of gathering information may be grouped under four divisions, as follows:

1. Collecting the facts through personal observation and experiment;
2. Collecting the facts through bibliographical research, the purpose of which is to ascertain what information on the subject has already been recorded in written form;
3. Collecting the facts through interviews, questioning verbally those who possess specific information on the subject which has not yet been recorded;
4. Collecting the facts through questionnaires, designed to obtain through correspondence, from persons located at a distance, specific information bearing on the subject.

While, for purposes of analysis and discussion, it is advisable to keep these methods definite and separate, yet in the actual carrying on of the investigation it is rare for any one type to be used to the exclusion of others. In fact, all four methods may be said to constitute the parts of a whole, and an investigation is not complete until all the resources of information have been drained to the practicable limit.

In no way should the foregoing statement reflect on the value of many kinds of investigations which are designed merely to collect data within a given range. Manifestly they are not intended to be complete investigations, as in most cases neither the necessity exists nor are time and money available for any more than a partial investigation of the subject.

The majority of business problems call for investigations

of this character, and while, as stated before, limitations of time and money of course establish boundaries upon the extent and character of the information that is gathered, nevertheless for the sake of forming accurate and dependable conclusions every available fact having a bearing upon the subject should be secured.

Another point to be considered in this connection is the sequence which has been assigned to these methods of gathering information. In the classification used in this discussion we have started with the simplest and most intensive type and proceeded to the most complicated and extended. While this arrangement has the merit of being logical and at the same time offers the most satisfactory opportunity to discuss and illustrate the use of each, it must not be inferred that it represents the sequence in which they should be used in every instance.

The practical investigator begins to gather information at the point where he can obtain it most advantageously. Perhaps this may be through personal observation on his part, but it is just as apt to be through interviewing some one with special knowledge of the subject or through reading the experience of others as published in written form.

As he proceeds with his investigation according to the tentative plan, the requirements of the particular case will lead him to draw upon one or another of these various methods of securing information until he has exhausted their resources or has proceeded as far as is demanded by the particular investigation.

BROAD OR INTENSIVE SURVEYS

In utilizing each of these methods of getting the facts, there are two standpoints from which the collection may be made. He may make a broad survey of the facts, and from the information thus obtained establish broad principles or laws which govern the action or relation of the facts, or he may make an intensive study of particular cases.

For instance, in one medium-sized manufacturing plant, the margin of profit had been steadily decreasing until it had reached a point where something had to be done. The management was undecided as to what was the cause of the trouble. The president was inclined to believe that prices were too low, while the treasurer felt that they were paying their salesmen larger commissions than necessary. On the other hand, the sales manager felt that the trouble lay with excessive production costs.

In order to find out definitely what the trouble was, an industrial engineer was brought in to make a thorough study of the business. Beginning with an analysis of cost and expense over the period since 1920, he found that there had been a steady increase in the cost per order. Analyzing this further, he found that while prices and production costs undoubtedly had something to do with this, the chief factor causing this increase was insufficient volume.

The factory was equipped to handle practically double the volume of business they were doing. With the same office organization, double the volume of orders could be handled without sacrifice of efficiency. The problem, then, was to increase the volume.

Reducing the price, however, would not, alone, accomplish this, as prices were in line with competitors' and the salesmen were not losing business on that account. Decreasing sales commission also would fail to increase the volume, as a large number of the salesmen were earning too little as it was and to reduce their net earnings further would mean an increase in the turnover of salesmen.

Production costs also, while they could be slightly reduced, were not high considering the present volume, but they could be materially lowered were the equipment worked to capacity. Centering his attack, then, on getting increased volume, the industrial engineer outlined a plan designed to open up wider fields for the use of the product. Bias and prejudice on the part of the executives had prevented them from getting the broad view of their problem. Once it was

disclosed, the necessary steps for solving the problem became apparent and within a year the additional volume of business was secured.

Here is a case where several problems seemed outstanding, but had an intensive investigation been made of any of these it would have failed to produce satisfactory results because none of these problems were fundamental.

There can be no absolute rule laid down as to which of these methods—the extensive or the intensive—is the better. In most cases, it will probably be found advisable to adapt one or the other of these methods in part, studying, say, certain operations as a whole extensively and then studying intensively other portions.

This method of making an intensive study of representative items is characteristic of the investigational procedure in a broad way. In fact, almost never is it possible to make a complete, extensive study of any problem. One must be satisfied with picking out representative facts to study and drawing conclusions from the consideration of these facts. This is known as sampling and is the type of research which is common in business. In carrying out this type of research, the procedure is in no way different from making a complete survey; but the success or failure in a very large measure rests upon the selection of typical or representative facts to be considered. Later on the question of how to make certain that the facts are representative will be taken up more in detail, but it is sufficient at this time to mention the matter so that it will receive proper consideration.

An example of a sales analysis of this type is the study of the telephone market which was made by the American Telephone and Telegraph Company.[1] The steps in this market survey were the following:

1. Selection of the survey area;
2. Division of the survey area into homogeneous market sections;

[1]E. L. Stone, Jr., "Forecasting the Future Market in a Large Community." *Harvard Business Review*, Vol. I, April, 1923. pp. 269-281.

3. Determination of the method or scheme of classifying and grading family types and business firms;
4. Preparation of record of existing subscribers and service by city blocks;
5. Field record and classification of existing families and business firms;
6. Summary of the field data.

AIDS IN UTILIZING THESE METHODS

Before taking up the four methods of collecting the facts individually, it may be well to discuss some general factors which materially aid the investigator in utilizing any one or all of these methods. These are:

1. Knowledge of the mechanics of research work;
2. Possession of a serviceable memory;
3. Knowledge of how to judge quickly the probable value of facts being collected.

All of the foregoing apply to the collection of data from whatever source they may be gathered. In some types of investigation, certain of these will receive greater consideration. Memory, for instance, plays a more important part in interviews than perhaps any other factor. Ability to record observations quickly and accurately and to judge the value of data is, however, common to all.

THE MECHANICS OF RESEARCH WORK

In making any observation with the expectation of utilizing the data in any way, care must be taken to:

1. Select the most desirable units in which to record the observations;
2. Get the observations in written form as quickly as possible.

Without reducing the facts to terms of a common denominator, recording, as well as consideration, of the data becomes impossible. On the other hand, since certainty as to the accuracy of facts varies inversely with the time when

they are set down in written form, and as accuracy is absolutely essential to success, it follows that taking notes of observations on the spot is highly desirable. This immediate recording of the observations is not always possible, as often is the case in interviews, but even then it is desirable to write up impressions immediately following the interview, while the matter is fresh in mind.

1. *Selecting the Units of Measurement.* Many of the facts gathered by the investigator, such as data showing output, sales, costs, and so forth, will rarely be considered as individual instances. Rather, this information will be combined, averaged, classified, tabulated, and summarized so that it can be readily grasped by the mind.

Conclusions, summaries, averages, and isolated facts form a pyramid, the foundation of which is composed of the individual observations of the investigator. As the accuracy of these observations depends upon the selection of the correct units of measurement in terms of which the data are recorded, it will be seen that the validity of the entire structure depends on the care exercised in determining these units.

From one standpoint units of measurement are either simple or composite. Simple units—for instance, the term "accident"—are those calling for but one consideration in their definition. Composite units, on the other hand, are those which call for more than one consideration; as, for instance, "industrial accident." This distinction is rather apparent, and while it is of certain advantage from a statistical standpoint, it does not usually assume prime importance in the average investigation.

From another standpoint a very satisfactory classification is that proposed by G. P. Watkins in an article in the *Quarterly Journal of Economics*.[1] It is as follows:

(*a*) Individual things, the quantity of which is determined by counting and which are further divided into:

[1]Volume XXVI, pp. 673 to 702.

(1) Natural kinds and events relating to natural things;
(2) Produced kinds and produced qualities of things.

(*b*) Mensurational units which are applied to determine quantity without regard to individuality and which are further divided into:
(1) Physical measure, that is, length, weight, capacity, and so forth;
(2) Measures of monetary value.

For comparative purposes these units are arranged in their descending order of value for use in expressing the facts gathered in an investigation. Units representing natural kinds are more definite and universal in their application than any other type and are, therefore, widely used. The census, for example, is largely based on this type of unit. Ordinarily, units of this class, such as, for instance, horses, cows, and so forth, are easily defined and, in fact, often require no definition. Counting is the only method of measurement used in recording data regarding these units.

Units of produced kinds differ only from natural kinds in that the objects have been modified for human use and purpose. Consequently, the definition and classification of these units depend on their function, as contrasted with the former type which depends on the natural form. Examples of this type of unit are automobiles, turret lathes, bricks, and so forth. Counting, as in the case of natural kinds, is a usual form of measurement, though in some cases physical measurement is introduced; as, for example, the capacity of a motor truck, the tonnage of ships, and so forth.

The third group consists of units based on physical measurement, such as length, weight, horse-power, and so forth. The size of such units is the result of accident and convention; as, for instance, the foot, which according to tradition was based on the length of the king's foot. In fact, many of these physical measures are so variable that facts expressed in terms of such units have to be defined every time they are used. An example in point is the output of a coal mine expressed in tons, without a supplementary note to indicate

whether the long or the short ton is the unit of measurement.

The fourth unit in which facts may be expressed is monetary value. It is the least desirable or accurate of the four types because the basis is abstract rather than tangible. The dollar is not a unit of the same degree of definiteness as a foot or a pound. That the dollar was worth 52 cents at one time and 64 cents at another clearly shows its lack of a fundamental basis. Then, too, financial facts expressed in terms of dollars are not comparable unless the figures in both cases are obtained in exactly the same way. Inasmuch as the accounting systems of most concerns differ, the content of financial statements vary and comparison becomes difficult, if not impossible, at times.

In gathering the facts in any investigation, the investigator may have to use any one or all of the foregoing types of units. Units of *natural kinds* may be employed in recording the facts regarding the number of employees, customers, dealers, and so forth. The facts regarding output may call for the use of *produced kinds* in order to show the number of pistons, cylinders, motors, and so forth, manufactured. On the other hand, in the case of a lumber mill, the most satisfactory unit of measurement may be the board-foot, which is a mensurational unit. Sometimes it is necessary to use the monetary unit to express output, sales, costs, and other statistics of business.

Because of the opportunity for choice in many cases, the investigator must exercise constant care in order that the proper unit may be chosen, and in making this selection he will find the following rules helpful:

1. Clearly define all units before attempting their use. This should be done at the time of the preliminary analysis of the problem, and any difficulties which may surround their use should be anticipated and considered as fully as possible at that time.
2. Put the definition in words if possible, as this is a great help in clarifying the unit in the mind of the investigator.
3. Make all definitions in such form that exceptions can be readily perceived. So far as possible, make misinterpre-

tation difficult, if not impossible, and the unit easy to apply.

4. The definitions should be practical and logical, based on the common and accepted understanding of the term rather than on a special meaning created for the occasion.
5. Refer all units of measurement to the conditions which produce or influence them, and use the same type of units consistently in connection with the same class of objects.
6. Avoid indefinite units or those of a character which are difficult to define easily.
7. Finally, bear in mind in selecting the unit that a classification, no matter how carefully prepared, is only as accurate as the units composing it.

2. *Taking Notes Effectively.* The ability to take brief and yet comprehensive notes on matters coming to the attention is a very important phase of investigational work. Time- and motion-study work, although calling for careful analysis of operations, yet in the main largely consist of the recording of data, so far as the operation itself is concerned. And the same is true of many other forms of investigational work.

Obviously, in some cases, it is necessary that the recording be complete in every respect, as failure to record a single element will often destroy the accuracy of the work. In other cases, however, it is necessary to record only the outstanding features, as, for example, when one takes observation of conditions in a department, or when one is making a market survey of a certain part of a city.

In all cases, however, where it is not necessary to record every single item, it is highly essential for the investigator to be able to seize upon the most important things which should be recorded, and get these down in writing, leaving many of the details and dependent items to the memory.

In taking notes, a loose-leaf notebook is most desirable. This enables the investigator to put on one page all observations relative to a given subject. He can then remove the notes from his book and file them under these subject headings for future use. Many engineers and executives

find it practicable to use 3 by 5 cards for taking notes of conditions. These can be easily slipped into the pocket, as they do not take up much space, and can be filed later.

Every engineer or executive undertaking the study of a problem involving numerical facts should be familiar with the use of the slide-rule, particularly the ten-inch type. The slide-rule greatly facilitates the performance of computations, especially percentages, ratios, and so forth, and is sufficiently accurate for all practical purposes.

The use of the stop-watch is becoming more and more common in making studies of operations, not only in the shop, but also in the office and in the field. In every case it has proved its value in enabling the separate elements in a job to be carefully recorded so as to permit the development of accurate standards for doing the work. Inasmuch as a great amount of material has been published during the last few years on the making of time studies, and since this is only a small phase of investigational work as a whole, we will not go into the technique of the use of the stop-watch further than to mention the value of this mechanical aid.

Whoever finds it necessary to make time and motion studies should study carefully a standard text-book on the subject, of which there are several that have been written by authorities. In addition, he will find a great many magazine articles indexed in the Industrial Arts Index under the subject heading "Time Study," that will give him invaluable pointers on the most desirable technique.

While there are other mechanical aids which are of great use in special investigations, they do not come into play in the ordinary business investigations, and therefore need not be mentioned at this time. For instance, the use of an electric recording wattmeter on many operations as described by W. W. Nichols in *Management in Manufacturing*, for November, 1925, page 259, will frequently furnish time information of great accuracy. The main point is for the investigator to find out what mechanical aids apply to the work at hand and then to utilize them to the limit.

THE VALUE OF A SERVICEABLE MEMORY

No matter how copious the notes the investigator may take or how fully he utilizes the mechanical aids which have been devised to help him in gathering data, he must depend upon his memory for a large portion of the facts observed, as it is physically impossible and frequently impractical to attempt to record everything.

A poor memory is, therefore, a great handicap, and it behooves the investigator, if he does not possess a good memory, to make a conscious effort to improve his memory capacity as much as possible. On the other hand, if he does have a good memory, it will pay him to develop it even better, as there is no such thing as too good a memory.

In striving to improve the ability to remember facts and information, it will be helpful to master some simple rules of memory-training which will be given later. But before giving these rules it will be well to discuss briefly the nature of memory.

Every act of remembering involves four steps: impression, retention, recall, and recognition. First of all, there is the impression of the thing observed through means of the proper sense-organs; the association of this impression with other similar or dissimilar impressions; the classification of the new impression and the placing of it in its proper niche; and finally, the retention of the thing thus classified.

Recall is the conscious effort to bring up the memory of this impression at a later date, and recognition is the act of identifying the memory picture which has been recalled.

Impression, therefore, is the first step in remembering. It furnishes the raw material, and, consequently, upon the clearness and definiteness of these impressions depends much of the ability to remember. It is therefore in connection with impression that the greatest attention must be given in order to cultivate a serviceable memory. However, clear impressions do not mean accurate recalling or recognition unless the other steps are functioning properly.

Each step must be developed equally, and to gain this desired result the following rules will be found helpful:

1. *Select what you want to remember.* Do not attempt to remember everything. Make your memory a filing cabinet and not a waste-basket. Do not try to remember data which can be easily ascertained from tables or books.

2. *Concentrate on the thing you want to remember.* Become entirely interested, observe closely, and thus form clearer impressions. The degree of concentrated attention determines the strength, clearness, and depth of the impressions received and stored away in the mind. To cultivate interest the following suggestions will be found helpful:

(*a*) Take steps to convince yourself that the subject is worth your while.
(*b*) Get better acquainted with the background and environment of the subject.
(*c*) Seek to discover a relationship between the subject and other things in which you are already interested.
(*d*) Subdivide the subject into its parts and give attention to each part separately.
(*e*) React wholeheartedly to the subject in question.
(*f*) Put the information to use.

3. *Endeavor to obtain impressions through as many channels as possible.* An impression received through sound and sight is at least twice as strong as one received through but one of these channels. You may remember a name or an event either by having seen it in writing or else by reason of having heard it, but if you have both seen and heard it you have a double impression and have two possible ways of recalling it. Not only is it advisable to utilize all possible channels of impression, but it is equally desirable to utilize as fully as possible the different channels. For instance, a student wanted to remember Ohm's Law—$I = E \div R$, where I=Current, E=Voltage, and R=Resistance. He found it helpful to use the following means of impressing this law upon his mind:

(*a*) He wrote the law many times, thus applying the principles of repetition.

(*b*) He pictured in his mind a man saying the formula and seeing it written on a blackboard, thus picturing it visually and applying the principle of vividness.

(*c*) He composed a jingle, thus making use of rhythm and rhyme, which are often great aids in making impressions.

(*d*) He concentrated trying to drive everything else from his mind but this formula.

(*e*) He imagined various associations which might be helpful in order to remember certain portions of this law.

(*f*) He also wrote the rule in various ways, thus applying the principle of variation.[1]

4. *Establish as many associations as possible.* It is through associations that the mind cross-indexes impressions. Each association which you establish makes it easier for you to remember or recall an impression. Endeavor to associate each new piece of information you receive with something already known and familiar to you. In this way you will avoid burdening your mind with a vast number of isolated impressions unrelated to other factors of your experience.

5. *Develop your weak avenues of impressions through intelligent training, exercise, and use.* Some people's memory is visual, that is to say, they can more easily remember things if they can visualize them in writing. Others remember sounds better; others remember by associating with related matters. Regardless of the way in which the impressions are received, consciously strengthen whichever of these sources of impression may seem weak, and thus add to the strength of the impressions you receive.

6. *Make your first impressions strong and firm enough to serve as a basis for subsequent ones.* Every time you bring out an impression, you deepen it, but if you have only a dim impression to begin with, the deepened impressions will not include details omitted in the first ones. It is like

[1]Adapted from a chart prepared by E. P. Hermann, and published in *Personal Efficiency*, January, 1923, p. 59.

enlarging a picture; the details lacking in the small picture will not appear in the enlargement, but those that do appear in the small one will be enlarged with the picture.

7. *Revive your impressions frequently and thus deepen them.* Whenever you wish to remember something, recall the impression a number of times. This brings repetition to your aid. With each repetition the impression is deepened and the liability of foregetting lessened. The use of repetition as a method of memorizing is too well known in schoolroom practice to require further discussion.

8. *Classify your impressions according to some logical plan.* This is but carrying out the idea of association to its ultimate. By associating the information you have secured with other information related to it and classifying all according to some definite plan, you will not only enable yourself to recall the point in question, but also the other related factors.

9. *Use your memory and have confidence in it.* This is perhaps the most important of all. Force yourself to rely upon your memory and you will find it grows stronger and more accurate. There are many details, of course, which it is folly to trust to the memory. In fact, the memory should not be used as a storehouse for a lot of useless information, but the effort should be made to concentrate upon those items which are of importance.

The importance of memory will be apparent when it is realized that memory lies at the basis of thinking. Through the memory the mind is supplied wtih the raw material in the form of concepts and judgments which the mind takes and properly classifies, with the result that inferences and conclusions are developed.

In fact, we can only think in terms of the mental images of ideas or concepts which are preserved in the memory. Hence, a good investigator must have a fairly good memory, but good as it may be, it is always desirable to have it

better. Every one forgets things or fails to remember them at the proper time. Whether the memory be good or lacking, organized training is beneficial.

One of the most helpful ways of training memory is to observe closely a miscellaneous collection of objects, such as the articles in a shop window, applying the rules of memory which have been given in the earlier part of this chapter. After concentrating on these objects for a few minutes, glance away and write down or repeat to some one else as many of the objects as you can, describing them as fully as possible. At first you will be able to name only a few, but with practice you will find your capacity increasing, and it will not be long before you have no difficulty in recalling the entire number.

TESTING THE FACTS

No business concern would consider the purchase of materials, merchandise, or service without maintaining sufficient inspection in order to check up deliveries as to quality and quantity. In like manner, the investigator cannot afford to accept the information gathered from any source without subjecting it to a careful testing, in order to make sure of its suitability for his purpose.

One of the most difficult, as well as the most important, problems facing the investigator is the weighing and testing of the facts he has gathered. Through personal observation, reading, conversation, and correspondence, he is in possession of a mass of material which bears many influences and contains many inaccuracies that will cause him to form untrustworthy conclusions unless these influences and inaccuracies are located. How can one tell the true from the false? How can he eliminate the latter? These are questions of the greatest importance, and their effective answer is secured only when the facts both those of a precise character as well as the indefinite types, are subjected to a careful examination and testing.

Part of this testing must be done while the facts are being collected. Those which meet the requirements are carried forward for further consideration. Those which do not meet the requirements are definitely rejected.

Of necessity, such testing must be practically instantaneous, for the main attention of the investigator at this time is directed toward making his collection of facts as complete as possible. Only after a considerable number of facts have been gathered is there a real opportunity for making the thorough and deliberate testing which will be taken up in a later chapter.

Both the preliminary and final inspections perform necessary services. The greater the care taken in checking up the facts as they are collected, the less time is required for the subsequent testing and the less likelihood is there that, on account of inaccuracies or inadequacies, it will be necessary to go back and do over certain parts of the work.

Naturally, during the collection of the facts there is no time for elaborate testing. The investigator, however, should have clearly in mind certain requirements which the facts must meet in order to be accepted. The character of this preliminary inspection differs somewhat in accordance as the facts are derived from personal observation or secondary sources of information, but the intent in all cases is the same.

1. *Testing Primary Facts.* During the observational process, or while conducting personal experiments, the adequacy of the facts will be fairly well determined if the investigator will keep carefully in mind the rules which are given in Chapter VII—Personal Observation and Experiment. Being devised primarily to insure that the collection of facts wil be adequate, it follows, therefore, that careful observation of these rules will constitute as much preliminary testing as is required in many cases. These rules, which will be explained fully later, in order to bring all the data together at this time are the following:

(*a*) Clearly formulate the problem.
(*b*) Assume the proper mental attitude.
(*c*) Make your observations selective.
(*d*) Get all the essential facts.
(*e*) Exclude all irrelevant facts.
(*f*) Get the proper perspective.
(*g*) Cultivate a questioning attitude.
(*h*) Make written notes.
(*i*) Consider the human element.

When collecting facts from personal observation and experiment, if these rules are kept constantly in mind it is reasonably certain that the facts carried over for further consideration will be pertinent and reliable.

2. *Testing Secondary Facts.* In deciding on the acceptability of facts gathered from secondary sources of information, such as books, interviews, and correspondence, an additional kind of testing is desirable. This testing bears a resemblance to that applied to evidence by the legal profession, in order to determine its value. These tests are as follows:

(*a*) Does the statement seem possible in itself?
(*b*) Does it seem probable?
(*c*) What circumstances prove it besides the testimony offered?
(*d*) Is the reference to authority for the statement definite?
(*e*) Is the authority competent to furnish expert information?
(*f*) Is he prejudiced or biased in any way?
(*g*) Has he had sufficient opportunity to know the facts?
(*h*) Is the information given the result of his personal observation or of hearsay?
(*i*) Is he aware of the significance of his statements?
(*j*) If there are more than one authority, do they agree?
(*k*) Has too great reliance been placed on one authority?
(*l*) Is the authority likely to be accepted?

The reliability of the source from which the information is derived determines in a large measure the value of the information. Largely, but not entirely, however; for the fact that an idea or practice has been accepted as true or best for many years is no proof that the same is true today. Likewise, the fact that a number of authorities vouch for its

truth or value means nothing when it can be positively demonstrated that the accepted view is false.

Time and time again the wisdom of personally verifying facts before accepting them has been proved, and the foregoing tests are very helpful for this purpose, together with others of the same type which the particular problem will suggest.

With this general introduction to the collection of the facts and the aids of various kinds that can be utilized by the investigator, we shall now pass to the detailed discussion of the four ways through which information on any subject can be gathered.

VII

PERSONAL OBSERVATION AND EXPERIMENT

Primary source of information. What is meant by observation. Sensations and their function. Attention. Simple rules for cultivating the ability to concentrate. Perception and its function. Developing the power of observation. Errors of observation and how to avoid them.

THE investigator is primarily a discoverer, an inventor, an originator of new methods of doing things or new combinations of old methods. Of a necessity, the primary source of his information must be his own experience, using that term in a broad sense so as to include everything that one feels externally or internally—in other words, the sum total of all of the impressions received through the various sense-organs.

There are two sources of experience. One is called *observation,* and is concerned largely with the recording of the things which come to one's notice. The other is *experiment,* wherein the things observed are changed in some way so that, at will, different combinations can be produced. Both are tied up with memory, for the things one observes can only be comprehended in terms of mental images or concepts of related matter preserved through the memory and recalled at the proper time.

Herschel has aptly remarked that these two modes of acquiring experience are really phases of observation, the one being passive, the other active in character. This brings out clearly the fact that observation is essential in both cases, but in the experiment, relations or conditions surrounding the facts are altered or changed to a greater or less degree.

Both observation and experiment are utilized in the course of an investigation but, taken by and large, observation plays a much more important part than experiment. In other words, the work of collecting the facts largely consists

of reporting what is seen and drawing conclusions from the consideration of the facts. Only in isolated cases or in peculiarly technical problems is it necessary to conduct experiments in a scientific manner.

However, the procedure of observation and experiment is based on the same fundamental laws, only the attitude of the observer being different. While, therefore, in this chapter, the discussion is based upon observation, the same rules and cautions hold for experiment as well, the latter being simply observation plus the alteration of conditions at will.

The best source of information for the facts bearing upon any particular problem depends somewhat upon the nature of that problem. In most business problems, while data bearing upon the fundamentals involved can be obtained from the experience of others, either in recorded or unrecorded form, in the main the most pertinent information must be secured first-hand through personal observation and experiment taken in conjunction with one's personal knowledge gained from previous experience. However, in many important and far-reaching investigations, such as market surveys which call for the collection of data from all sections of the country, dependence must be had upon information secured through questionnaires or through reports of field men.

Without, however, depreciating in any way the value of the information which can be secured through other sources, it nevertheless is a fact that the things which one experiences himself make a more lasting impression than information gathered in any other way. No matter how far-reaching may be the conclusions of another on a given subject, they do not gain a true significance until they have been incorporated into one's personal experience.

WHAT IS MEANT BY OBSERVATION?

Realizing, then, the importance of personal experience, it may well be asked: "What is observation and what is in-

cluded in the meaning of this term?" Observation is the act of looking closely at an object as a whole, at the same time taking in its details.

Observation is more than merely seeing, or looking at, things. Thousands of objects flash before the eyes during the day which are seen but which leave no impression. This distinction is well brought out in the following quotation from the *Adventures of Sherlock Holmes*, by A. Conan Doyle:

I could not help laughing at the ease with which he explained his process of deduction.

"When I hear you give your reasons," I remarked, "the thing always appears to me to be so ridiculously simple that I could easily do it myself, though at each successive instance of your reasoning I am baffled until you explain your process, and yet I believe that my eyes are as good as yours."

"Quite so," he answered, lighting a cigaret and throwing himself down into an arm-chair. "You see, but you do not observe. The distinction is clear. For example, you have frequently seen the steps which lead up from the hall to this room."

"Frequently."

"How often?"

"Well, some hundreds of times."

"Then how many are there?"

"How many? I don't know."

"Quite so! You have not observed. And yet you have seen. That is just my point. Now, I know there are 17 steps, because I have both seen and observed."

From the foregoing definition it can readily be seen that observation is not a simple act but is made up of several distinct elements, which are named *sensations, attention,* and *perception.* While observation is largely seeing with a purpose, yet no small part of one's experience is gained without any distinct purpose. Every time the eyes dwell on an object, something is seen which may be of value at some future time. Hence, it is wise at all times to form the habit of observing closely, so that clear impressions are passed on to the memory for future use.

For that reason every one engaged in business or commer-

cial work, and especially one entrusted with the direction of work, should cultivate his powers of observation to the utmost. While certain individuals are undoubtedly born with keener eyesight or sharper senses than others, the power of observation is almost entirely an acquired faculty. It is, therefore, within the power of every one to acquire the ability to observe closely and accurately, provided he understands thoroughly the scope and significance of the various elements composing the act of observation.

SENSATIONS AND THEIR FUNCTION

Sensations are the first products of observation. They are the direct feeling of things or bodily conditions. They are the impressions that are gained entirely or partially through the various sense-organs as distinguished from what one thinks when none of these exercise any influence on his thought.

The senses give information of what is going on in the outside world. The promptness and accuracy of the reports of the sense-organs depend on their keenness. Naturally, any impairment of these organs weakens the observational power and that is why the investigator should be free from bodily defects.

With training, the bodily senses can be made to register extremely accurate reports, just as accurate as the natural endowment in the way of eyesight, hearing, and so forth, permits. The "telephone ear" is an example in point. From frequent use of the telephone, most persons are able to hear better with their left ears than their right, because the majority, being right-handed, hold the receiver exclusively to the left ear.

Science, in the form of magnifying, measuring, and recording apparatus of many kinds, furnishes the observer with additional tools to aid him in recording accurate impressions, and the investigator should be familiar with the use of every type of equipment that can aid him in his work.

But there is always one drawback to the perfect observation of any event or situation. This lies in the personality of the observer. As Bacon has said, "The mind of man is like an uneven mirror, and does not reflect the things of nature without distortion." The man who can with perfect fairness register the facts observed, without being swayed by prejudices and with careful attention to detail and conditions, is very rare, indeed. But toward this ideal the investigator must strive.

ATTENTION

Attention is defined as the application of mind to a mental state. In other words, it is the act of concentrating on a subject.

It is commonly believed that, whenever objects affect certain sense-organs, feeling, hearing, tasting, or smelling, and so forth, results. This is only partially true. The real truth is that one becomes conscious of the reports of these sense-organs only when the attention is directed toward the sensation either voluntarily or involuntarily. For instance, the clock may strike loudly, but one may not hear it, or at least not be conscious of the fact that it is striking, if he happens to be deeply interested in a book, game, or work of some kind.

Attention is divided into two classes: involuntary and voluntary. Involuntary attention is caused by the nervous response to some sense stimuli. When one becomes engrossed in something of vital interest without having had a voluntary desire to do that thing, it is an example of involuntary attention.

Voluntary attention, on the other hand, is that which is directed by the will to some object of a more or less deliberate selection. It requires will-power and determination to force the attention to things which may not be interesting. Voluntary attention, therefore, is the result of training and experience and the exercise of will-power and

determination. In fact, some authorities go so far as to say that what is commonly called will-power is only a developed form of voluntary attention, the man of strong will-power holding before him the one idea which he wishes to realize.

It is needless to say that voluntary attention is essential to observation, and the aim should be to train the attention so that it will become as nearly involuntary as possible. In other words, instead of being obliged to focus the attention at every instant to the thing being observed, the aim should be to have the attention, once directed toward an object, stay with it until the information desired has been secured.

That the voluntary attention may be deliberately trained and developed is a fact that has been demonstrated time and time again. There is but one way to do this, and that is through practice. By practice, interest is aroused in subjects previously uninteresting. By studying and examining an object closely, attention brings to light many new and interesting features which produce added interest. This, in turn, attracts continued attention and makes concentration easier.

SIMPLE RULES FOR CULTIVATING THE ABILITY TO CONCENTRATE

In developing the power of attention or the ability to concentrate, some very helpful suggestions are the following:

1. *Pick out the subject to which the attention is to be directed.* Think out carefully the things which you want to observe, proceeding first to the most important things to be noted, and then to those of lesser importance.

2. *Focus the entire mental capacity on the act of observation.* The rays of the sun shining on a piece of paper through an ordinary window pane are harmless indeed, but when the same rays are gathered together by means of a magnifying glass and brought to focus on the paper, fire is

produced. In like manner, the direction of the attention closely upon an object is equally efficacious in obtaining pertinent information which could not be secured otherwise.

3. *Cultivate a real interest in the matter under observation.* This is vital, for without real interest it is difficult, if not impossible, to stimulate close attention. Pretend an interest, if necessary, but one way or another develop interest, or otherwise it will be difficult to observe closely. This is well brought out by William James:

> No matter how scatterbrained the type of man's successive fields of consciousness may be, if he really *cares* for a subject, he will return to it incessantly from his incessant wanderings, and first and last do more with it, and get more results from it, than another person whose attention may be more continuous during a given interval, but whose passion for the subject is of a more languid and less permanent sort.

4. *Keep the mind on the subject.* Do not allow other matters to attract the attention and cause the mind to wander from the matter being observed. As the athlete disciplines his body, so one must discipline his mind, in order that effective results will be secured.

5. *Work under favorable conditions.* While this is not always possible, the advantage of working under the most favorable conditions requires no proof. Especially is it necessary in the beginning when the attention is being trained. After one has trained the attention, he can concentrate anywhere.

6. *Relax at intervals and rest the mind,* just the same as the body is given periods of rest when it is engaged in hard manual work. Concentration utilizes considerable energy and vitality. Rest and relaxation should be provided, therefore, so as to enable the body to build up its store of energy and vitality.

There is no royal road to the acquirement of the ability to concentrate. It takes work, practice, and use; and in addition it requires the moral qualities of sincerity, honesty, and

earnestness of purpose, without which but little can be accomplished.

PERCEPTION AND ITS FUNCTION

The application of attention, either voluntary or involuntary, to the reports of the senses makes possible perception; that is, the actual interpretation of these reports by the mind.

Contrary to ordinary belief, everything reported by the senses is by no means perceived. The brain is but a mirror, in which are reflected thousands of impressions which never reach the mind. While perception depends upon the reports of the senses for its raw material, it relies entirely upon the application of the mind for the utilization of these reports.

The distinction between sensation and perception, therefore, is the difference between a simple report and the thought arising from consideration of the report. By sensation the mind feels or sees; by perception it knows that it feels or sees and recognizes the object causing the sensation.

Besides thinking about these reports from the senses, perception performs another function, which is that of grouping and identifying the sensations, drawing upon the memory of past experiences, the imagination, and thought, in order properly to place new sensations.

At this time it may be well to draw a distinction between the forming of perceptions and thinking. The observational process, as a whole, requires the use of thinking, but not of the same type or to the same degree as is called for in the later procedure of investigation. In observation the thinking involved is of the most simple type. Animals have developed splendid powers of observation, far beyond that which man possesses, but it is very much disputed as to whether or not they think.

Even admitting that some animals do think in a crude way, there is no comparison between the simple form of such assumed thinking and the elaborate reasoning of the adult

mind. Therefore, it is clear that the thinking required in the process of observation is not at all of the character which is demanded later, and hence the discussion of the subject of thinking will be left to a later chapter.

Taking up again the formulation of perceptions, it will be found that this takes place in three gradual steps:

1. Through conscious attention, definite sensations are received from the various sense-organs.
2. These sensations are interpreted by the mind and attributed to the outside object causing them.
3. Related sensations are grouped together, their unity perceived, and they are noted as qualities of the outside object.

It is of the utmost importance that the powers of perception should be developed, for therein lies the ability to interpret properly the evidence of the senses. Most people go through life without perceiving even the most obvious facts. Their eyes and ears are perfect instruments; their nerves convey accurate reports, but the perceptive faculties fail to interpret and utilize the reports furnished.

Power of perception can best be trained by cultivating a questioning attitude toward whatever comes into the experience. Take nothing for granted. Find out the reason why. The possession of the ability to form clear perceptions comes primarily through training. Perception being essentially a thinking process, it follows, therefore, that the cultivation of the ability to think straight and to form accurate judgments naturally results in developing the power of perception. The study of logic, mathematics, and the natural sciences is helpful and especially recommended.

DEVELOPING THE POWER OF OBSERVATION

Observation, it has been seen, being made up of three elements—sensation, attention, and perception—it follows directly that whatever helps in the formation of clear impressions and the delivery of more accurate impressions to the mind naturally increases the ability to observe.

In like manner, the more closely one is able to concentrate on a subject, the less he is apt to miss and the more complete will be the reports furnished by the sense-organs. And, finally, the more accurate his processes of reasoning the greater the gain all around and the less likely is he to make inaccurate or incomplete observations.

But, aside from the foregoing general suggestions bearing on the cultivation of the observational power, there are a number of specific rules which will aid the investigator in successfully applying observation to the analysis of any business problem. These are as follows:

1. Formulate the problem clearly.
2. Assume the proper mental attitude.
3. Observe one thing at a time.
4. Get the proper perspective.
5. Get all the essential facts.
6. Exclude all irrelevant facts.
7. Cultivate a questioning attitude.
8. Make written notes.
9. Consider the human element.

1. *Clearly Formulate the Problem.* It is a waste of time to make observations or to gather information of any kind until the problem has been formulated and it is known exactly what is wanted. It has been seen how essential the preliminary analysis is to the investigation as a whole, and it is of equal value as applied to a portion of the investigation. Many times the investigator is set adrift without any definite instructions as to what is desired. When this is the case, his first step must be one of definition, the purpose of which is to formulate the problem and determine the points requiring careful observation.

2. *Assume the Proper Mental Attitude.* The mind must be open and free from prejudice in order to make accurate observations. Emphasis has already been placed on the importance of eliminating, or at least controlling, prejudice. While this control is essential before beginning the work of

observation, it is even a greater necessity to maintain it throughout every step of the investigation.

This will require constant self-discipline, in order to refrain from forming opinions as the facts are gathered and in that way allowing one's self to become prejudiced before sufficient facts have been gathered upon which to base an accurate judgment.

One danger, at all times present in gathering information, is that the investigator will formulate an opinion based on the first few cases noted. He thus lets himself become prejudiced, and this influences his further collection of information. For instance, a young man was assigned to collect information from druggists. It so happened that the first few drug stores called on were located in a portion of the city which had a large foreign population. The information received, therefore, was along much the same line, and after making out several reports, the investigator formed a hasty conclusion as to the opportunities of sale for the products in question. When later, in other portions of the city, he encountered contrary information, he found it rather difficult to rid his mind of the opinion which he had formed and in the end draw a conclusion which was dependable.

It is said that the essential factor of learning is an active attitude of mind and a deep-seated desire to learn. So it is with the investigation of any problem. The mind must be alert, and there must be a sincere and genuine desire to find out the true facts.

3. *Observe One Thing at a Time.* Select the most favorable subject for observation at the beginning. This makes more rapid and effective progress possible. In addition, it is well to view the selected subject under the most favorable circumstances for gaining a true picture of conditions.

For example, in time-study work it has been found best to make time studies of first-class workmen only, and these men should be timed only when working at their best. The worker being studied must be made to realize the purpose

and importance of the measurement of his motions and the time they require for their performance, and the observation should be made only with his full knowledge and ready cooperation.

The best worker observed in time- and motion-study work is one who is so skilled that he can perform a group or cycle of prescribed elements or standard motions automatically, repeating the same elements or motions.

In like manner, in utilizing observation in other ways, the selection of time and place for observations is of the utmost importance. Only by careful selection is it possible to insure that the main points requiring consideration will be brought out, and opportunity afforded to study these under the most favorable conditions.

4. *Get the Proper Perspective.* Closely associated with the foregoing is the necessity of getting the proper perspective. A very frequent cause for failure to observe accurately arises from the inability to see things in their proper relation to the problem and to each other.

The bodily senses of every normal individual react to the laws of illusion. A silk hat looks higher than it is wide, and yet the dimensions are usually the same. Fortunately, an illusion is only apparent and vanishes when subjected to actual measurement. In business problems, however, there are many things which come under the observation which cannot be measured physically.

Hence, in order that a true measurement may be made, it is essential that the investigator should be on the alert to get the true view of these things. In a later chapter on "Testing and Interpretation," practical rules and examples will be given, showing how this source of error may be eliminated from one's observations.

Some of the chief objections to time-study work may be traced to mistakes of this description, which have been made in times past. A bright young technical graduate will be carefully trained in the technique of the stop-watch until he

is able to record accurately elemental time. He will then be turned loose in the shop or factory to make observations on work at which he may have little or no experience.

It is only natural that the true significance of many of the elements noted will entirely escape him, and the standards which may be developed from these observations may be of questionable value. Of course, if he is given proper supervision, such disastrous results may be avoided, but very frequently such supervision is lacking, and time study has received the blame for the resulting failures.

5. *Get All the Essential Facts*. No observation is complete if a single vital fact has been overlooked. One of the most frequent causes for failure of investigational work can be traced directly to the violation of this rule. Every fact having a bearing on the subject must be carefully examined for its significance. It is only too frequent that a whole series of observations will have to be thrown out because the observer failed to note that the belt on the machine he was studying was either too tight or too loose; that the gear or pulley ratios differed; that surrounding conditions were not comparable; or that the quality of the material varied.

The head of the billing department of a large commercial house was desirous of finding out the standard time for the operation of bill posting, which time could be used as a standard in developing a bonus on this work. He made what he considered very careful time studies of this work but confined his observations solely to the apparent elements of the bill-posting operation and took no note of the variable elements, such as changes of address, cards out of file, fatigue, personal time, and so forth.

Analysis of his observations showed that the standard time for the bill-posting operation was 19 seconds, or approximately 1,400 postings per day. However, the output records which had been kept for a long period showed that the largest number of postings made in one day by the fastest girl was 750, and he quickly realized that something was

wrong with his studies, although it was not until an engineer had shown him the proper way to make a time study that he was able to discover his error.

Herein lies the superiority of elemental as compared with over-all time studies. It is only by analyzing an operation that the essential elements can be discovered, and it is only by timing these separately that an accurate standard time can be developed from the studies. In order to make certain that no vital element will be overlooked, the following instructions for time-study men have been found practicable.

Instructions to Time-Study Men

In making time studies of any operation, keep the following points in mind:

1. *Study of the Machine.* In studying an operation that is performed on a machine, consider the following:

(*a*) Can the work be done in multiple?

(*b*) Can an automatic feed be arranged for?

(*c*) Can some machine motions be eliminated?

(*d*) Can the machine speed be increased?

(*e*) Can the operation be divided into two or more smaller operations involving a shorter sequence in their cycle?

(*f*) Can the operation be combined with other operations to advantage?

2. *Study of the Material.* In the study of an operation involving the use of material, consider the following:

(*a*) Is the work in proper condition when brought to the operator?

(*b*) Is there, or has there been, any noticeable change in quality of material which would affect production?

(*c*) Have exceptional cases been sorted out before the work is brought to this operation?

(*d*) Is the work placed in the proper position in relation to the machine and the operator?

(*e*) Is it always placed in the same position?

(*f*) Are there any lost motions or motions of too long duration in removing and placing the work aside when the work is completed?

(*g*) What delays are encountered due to delivery of work to the operator?

(*h*) Are these delays reduced to a minimum?

3. *Study of the Tools.* In the study of an operation involving the use of tools, consider the following:

(*a*) Are the tools used in good condition?

(*b*) Are they the best kind of tools for this class of work?

(*c*) Are the same kinds of tools used on all similar operations?

(*d*) Are the tools of such a nature as to cause an unusual amount of fatigue?

(*e*) Where two or more tools are used, observe whether these could be combined into one tool, so as to eliminate motions of picking up, removing, and laying down tools.

(*f*) Are tools placed in such a position on the machine that no "fumbling" takes place when they are picked up?

(*g*) If the operation is metal-cutting, is the heat-treatment process through which the tools are put such as will produce the best results?

(*h*) Are the cutting angles of the tools standardized?

(*i*) Are the tools sharpened by the operator, or by a centralized grinding department?

(*j*) Are the tools numbered or symboled, and how are they obtained from the tool-supply room?

4. *Study of the Worker.* In every operation where a workman is required, except in those operations which are strictly "process operations," consider the following:

(*a*) Does the operator assume the correct position with relation to his machine, bench, or work place?

(*b*) Is the work done jerkily, spasmodically, or smoothly?

(*c*) Is the worker overexerting himself or herself as compared with other workers on the same kind of work?

(*d*) Is the worker turning out less output than the other workers?

(*e*) Is the worker the right person for the job?

(*f*) Comparing the motions of one worker with those of another, does one worker use more motions or longer motions than the other? If so, why?

(*g*) Are there any awkward motions?

(*h*) Does the worker go through the same sequence of motions for each cycle?

(*i*) What will be the *best motions for the standard cycle?*

(*j*) What will be the *best sequence* of these motions?

(*k*) Can the work be so arranged that right- and left-hand motions can be performed at the same time?

(*l*) Is the relative position of the worker when sitting or standing the same with regard to machine or work place?

(*m*) Must the worker assume an awkward position because of poor placing of the machine?

(*n*) Observe the arm movements of the worker. Can an arm rest be designed so as not to interfere with the motions but at the same time reduce fatigue?

(*o*) Is the light arrangement such as to eliminate fatigue due to eye-strain?

(*p*) Are the ventilation, temperature, and humidity of the room regulated for the class of work performed therein?

(*q*) Is provision made for the worker to sit down if the work permits, and is the best type of chair used?

(*r*) Are conditions such as to reduce physical and mental vitality?

(*s*) Can any changes be made that will reduce nervous strain?

(*t*) What regulations and applications are in use for safeguarding the worker?

(*u*) What periods of the day are points of high production in the operation?

(*v*) What periods of the day are points of low production in the operation?

(*w*) Can rest periods be arranged so that production will be maintained at a high level throughout the day?

(*x*) What "fatigue factor" will it be necessary to use for this class of work?

(*y*) What allowance should be made for personal time?

Complete consideration of these questions, when making time studies, will be of material help in analyzing a situation and planning the work for its performance to the best advantage. In fact, time and motion study is only a specialized form of personal observation combined with some experiment. While subject, however, to the basic laws given in this chapter, because of its specialized character, any one needing to make time and motion studies should study care-

fully a standard book on the subject, such as *Time Study, as a Basis for Rate Setting*, by Dwight V. Merrick, or *Time Study and Job Analysis*, by William O. Lichtner.

6. *Exclude all Irrelevant Facts*. This rule is a converse of the preceding. Just as it is absolutely essential to note every vital element, so is it imperative that none but vital elements be considered. Violation of the preceding rule is usually the result of a lack of experience in observational work, physical defects, or the failure to concentrate on the subject. Violation of the present rule, on the other hand, may be traced largely to the possession of mental defects discussed in the section on prejudice, and unless these are controlled or eliminated the value of the investigator's work will at all times be subject to question.

Not long ago a journalist located in one of the mid-western cities made a study of the influence of automatic machinery on the worker. The result of his investigation appeared in the form of a book in which modern machinery and methods of manufacture were severely indicted. Although this work was written in a very interesting style, it was patent at all times that the conclusion was the motivating influence which had prompted the investigation. Blinded by the desire to prove his assumption, he was led to see things which were not there and to inject into the problem elements which had no true relation to it. In that way what otherwise might have been a very valuable addition to the science of economics was lowered to the region of socialistic propaganda.

7. *Cultivate a Questioning Attitude*. The old philosopher Bacon says, "He that questioneth much shall learn much." Develop the faculty of intelligent curiosity. It is one of the most valuable faculties that the investigator can possess, as it leads to the discovery of new methods, and ideas. Because a thing is done in a certain way is no reason whatsoever why that way is necessarily right. In fact, if it has been performed in that manner for a long time, the chances are that the method is wrong.

Develop the powers of initiative and originality in working out new and more profitable ways of doing things which come under observation. Be amenable to the suggestions of superiors, and follow helpful advice bearing on the general plan of the work. Do not depend upon them, however, for instructions covering the carrying out of the details. If one expects to become a real investigator he must be able to carry out this part of the work with a minimum of supervision and direction.

It is said of one of the leading industrial engineers, who possesses this faculty to a great extent, that it results in compelling his associates to think. No one can meet him without being forced to investigate and reflect. No habit is safe from his scrutiny. He is incessantly asking—why?—what for?—how much?—how do you know? In one of Kipling's poems this little couplet occurs that is well worth keeping in mind constantly:

> I keep six honest serving men;
> They taught me all I know,
> Their names are What and Why and When
> And How and When and Who.

8. *Make Written Notes.* Although the investigator should have a good memory, he should not trust it entirely for the preservation of his observations. His chief use of memory is in the recall of similar situations previously encountered and the recollection of what was done at that time, or where he can find certain information relative to the subject.

The investigator should carry along with him at all times a notebook in which he can jot down important facts while they are still fresh. Not only facts themselves should be noted but ideas occurring in connection with them. Many of these ideas, while not applying to the immediate step, may apply to later steps, and by writing them down when they occur, there is less danger of their being lost or forgotten.

While special forms, such as the Time Observation Record shown in Figure 2, are desirable, in many cases it will

be found that a loose-leaf notebook of pocket size is best for the purpose of recording notes. The observations recorded should be indexed under logical headings and filed, together with ideas, in their proper places.

It is especially helpful to make as complete a preliminary

Date	TIME OBSERVATION RECORD	Part No.

Part Name	Used on	Drwg. No.
Operation		
Machine	Machine No.	Dept.

Material	Length	Width	Thickness	Parts per strip

Employee	Performance	Obs. taken by

OPERATION DATA

Element No.	Speed			Feed			Limits of Dimensions	Tool Number	Tool Name
	Spindle R. P. M.	Cutting F. P. M.	H. S. or Carbon Tool	Per. Rev.	Depth	Length of Cut			

OPERATION ANALYSIS

Element No.	Element	Actual Time												Selected Time
		Reading	Elapsed	Reading	Elapsed	Reading	Elapsed	Reading	Elapsed	Reading	Elapsed	Reading	Elapsed	

DETERMINATION OF FACTOR

Incentive	25%
Personal	
Fatigue	
Machine	
Oper. (tools-guage-etc.)	
Misc.	
Total	

Total Selected Time	
Factor	
Standard Time	
Approved by	

Figure 2: Blank for recording observations, designed by R. J. Rahn, industrial engineer.

analysis as is practicable of the subject being investigated and have the divisions of the notebook correspond to the divisions of this analysis. In that way the analysis itself becomes a sort of a check list or guide and makes certain that no essential information will be overlooked.

For instance, the committee which was appointed by Herbert Hoover to investigate waste in industry spent a considerable amount of time at the beginning of its work in drawing up a questionnaire,[1] designed to bring out the most important information which it thought it necessary to obtain. Any one called upon to make a survey of a manufacturing establishment will find that the questionnaire developed by this committee will offer a splendid means for organizing his attack on the problem, as well as a means for recording his observations in a clear and definite manner.

Of course, it is seldom that the exact questionnaire or the exact method of recording observations which is successful in one case will precisely fit another. Every business is different in certain respects, although subject to the same fundamental laws and principles in its operation. Because of these differences, however, in physical or financial advantages, personalities and policies, it is necessary for each problem to be attacked on its own merits.

9. *Consider the Human Element.* In the investigation of any problem, the most important element to be observed is the human element. The shortcomings of many so-called efficiency engineers in this respect are well known, so that special emphasis on this point is hardly necessary. The violation of the rule, however, is still so frequent and so inimical to the securing of profitable results that a brief discussion seems advisable.

Almost all the important points which should be considered in connection with the human element are noted in a previous section of this chapter, to which reference should be made at this time. How the failure to give proper con-

[1]Given in full in *Waste in Industry*, Chapter IV, pp. 34-49.

sideration to the human element can spoil what otherwise is excellent investigational work may be best illustrated by quoting one of the leading industrial engineers:[1]

> A number of years ago one of the now leading efficiency engineers was engaged in a large industrial plant to introduce a piece-work system. For two years he labored; stop-watch in hand, he timed the various operations and tabulated the results. His attitude toward the workmen was impersonal. He was a scientist (?) in his laboratory. He was a man apart. The men around him recognized him as such. Lacking their confidence, cooperation was impossible. When he appeared in the shop and began his observations, machines would often be slowed down, with loss of output, or speeded up, with damage to tools. Every device known to the various trades was resorted to, to block him at each turn. The result was that after two years of effort the establishment of a satisfactory piece-work system was as far from realization as it had been when the task was started. Then a practical man was called in. He acquainted himself with the machines and their capacity. He mingled with the men and gained their confidence. He explained that the object in view was twofold, to increase the output at a reduced cost per unit to the company and at the same time to enable the men to earn more. Within six months he had accomplished results that the efficiency man had spent two years in an effort to secure. Why? Because he appreciated the importance of the man element.

ERRORS OF OBSERVATION

Violation of the foregoing rules of observation results in inaccurate observations. No matter how correct may be the processes of reasoning carried on, if the premises are unsound the conclusions are bound to be in error. Therefore, it is essential that accurate data be passed on to the mind for consideration.

Errors of observation fall into two broad classes. The first of these may be called mal-observation, which is the result of seeing wrongly. The second may be termed non-observation, which is usually the result of overlooking or failure to see things which should be seen.

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[1]Thompson, C. B., Editor, *Scientific Management*, Harvard University Press, p. 619.

The former is largely the result of mental or temperamental weaknesses. The latter results both from physical and mental shortcomings. Both types of error may be avoided if the investigator will constantly check himself up by questions, such as the following:

1. Are conditions right for a correct observation?
2. Are any of my bodily senses impaired?
3. Do I need glasses?
4. Is my hearing good?
5. Am I too tired to observe closely?
6. What influence has habit on my observation of the conditions in question?
7. What influence has bias or prejudice on the observation?
8. Has there been any lack of attention, or misplaced attention during the observation?
9. Is my training sufficient to observe closely and correctly?

Training in observation consists largely in overcoming the errors of mal-observation and non-observation, and the nine rules which have been given in the chapter are a great help in accomplishing this purpose.

Any one who frequents law courts knows how apt the individual is to make inaccurate observations. Persons of good intelligence often differ widely in their description of even the most simple event. Hence the need to keep the foregoing rules constantly in mind and at all times be on the alert to avoid any violation of them.

In fact, the ability to observe closely and record observations accurately is the main thing which distinguishes the trained from an untrained investigator. The former, knowing how to observe correctly, can go into a shop or office and in a few minutes find out more details about conditions than the untrained man can discover in as many hours.

Many industrial engineering concerns and research agencies engaged in investigational work of a distinct type have worked out more or less elaborate procedures for the guidance of their staff men. These procedures have a dual value. They point out the most desirable way to get essential in-

formation and at the same time they train the investigator in the development of his observational faculty.

Such procedures do not restrict the investigation in any respect nor make it a cut-and-dried affair. They simply make sure that matters of cardinal importance will be properly considered and reduce the probability of incomplete or faulty observations.

VIII

BIBLIOGRAPHICAL RESEARCH

Drawing on the resources of recorded experience. Bibliographical research. When and where to use it. Available bibliographies and indexes. How to use bibliographical research effectively. Indexing unclassified data. Sources of specialized data: (1) trade associations; (2) chambers of commerce; (3) technical societies; (4) governmental bureaus; (5) private research agencies. Utilize resources to the utmost. Other sources of recorded experience.

One of the principal faculties which has enabled man to raise himself above the level of the animals is his greater capacity to make use of experience. Where the animals have to depend on their physical organism for the preservation of useful information, the invention of speech and writing gives mankind the power of multiplying his experience manifold. In fact, it may be said that the progress of mankind has been in direct ratio with his ability to record experience and, hence, the importance of knowing how to draw on these records to the limit.

All the knowledge and experience gained from others comes under the classification of "secondary sources of information," not at all because it is of less importance but simply because it has been borrowed from others and is not directly and personally acquired. In fact, valuable as is personal observation and experiment, the results in the majority of cases would be but meager if reliance were had solely in one's own power of observation and the help of other workers on the same field were not enlisted.

It would be hard to name a single great invention that has been the unaided product of one man. Many minds have cooperated in bringing an idea to its full fruition. What a strange looking mechanism the first automobile is beside an up-to-date model. The constant improvements which have been plainly visible from year to year have been made pos-

sible by the fact that each designing engineer has been able to carry on from the point where others have left off.

These secondary sources of information contain knowledge and experience of various kinds and values. Some appear in written form; some exist only in the minds of certain individuals. All this wealth of information may be tapped in three ways:

1. Through bibliographical research, finding what experience has been recorded in written form;
2. Through interviews, talking with those who possess desired information;
3. Through questionnaires, ascertaining by correspondence the information that can be secured in no other way.

In like manner, as personal observation was analyzed and discussed, so will it now be profitable to examine each of these methods of gathering the facts. But it must not be forgotten that while for purposes of analysis it is advisable to differentiate personal observation from the three methods just mentioned, yet personal observation and experiment must play an important part in the utilization of any method of collecting information, for it is only through the medium of personal observation that the data can be brought to the attention of the mind.

All, therefore, that has been said about the value of accurate observation is applicable at this time, in connection with the use of these means of securing the facts.

BIBLIOGRAPHICAL RESEARCH

Thomas A. Edison says: "When I want to discover something, I begin by reading everything that has been done along the line in the past; I see what has been accomplished by great labor and expense in the past; I gather the data of many thousands of experiments as a starting point, and then make many thousands more."

No one will question the fact that it is of great importance to find out what has already been done, when undertaking

investigations for the purpose of invention or discovery. That the same is true when investigating any business problem is not always realized. In fact, it has required the persistent effort of engineers like Taylor, Gannt, Emerson, and many others, to make business men see that the same procedure which secures good results when applied to a "scientific investigation" is equally applicable to the solution of the ordinary business problems.

This fact has been very clearly brought out by Henry Morgenthau in an article in *System, the Magazine of Business,* sometime ago on the subject "What Business Men Have Learned Since 1900." He states that one of the most important lessons is that:

> Buying, making, and selling are really scientific operations which demand the interchange of knowledge as among scientists and there should be available to each man the sum of this knowledge. This conviction, which is becoming general, has been largely brought about by the establishment, growth, and service of publications which act as roundtables for the interchange of experiences. America is forging to the front in the knowledge of the science of business because no other country is as well equipped with books and periodicals making available past and present practice. And consequently our knowledge of business is available to every one and not confined to only a few.

Not all business men have learned this lesson. There are still many who rely only on their own experience, and millions are lost every year due to the lack of vital information which could have been secured. In most cases the failure to keep posted on the latest developments in business is not from deliberate refusal, but simply because the average business man does not know what rich sources of information are open to him, and it is the purpose of this chapter to show how these resources can be opened up for his use.

WHEN AND WHERE TO USE BIBLIOGRAPHICAL RESEARCH

Before taking up the various kinds of recorded experience which are at the disposal of the business man, engineer, and

investigator, there is one matter which should receive consideration. This has to do with the decision as to the point where and the time when it is most advisable to do this bibliographical research.

Desirable as it might seem to assign some definite position to this means of acquiring information on a subject, it is absolutely impossible to do so in actual practice. While nearly every investigation calls for reference to recorded experience, if it is only to the company's own records, yet the time when it is best to look up these data varies anywhere between the beginning and the end. Every investigation is a law unto itself in this respect, and the only rule that can be laid down is to bring bibliographical research into play before any final conclusions are formed. But how far the consultation of written records shall be carried must largely rest upon the judgment of the individual in accordance with the requirements of the particular problem.

For example, in one case an engineer, given the problem of devising a better method of hardening gears, found it to his distinct advantage to read up thoroughly on current heat-treating practice before conducting any personal experiments. In this way he materially limited the scope of the problem to be solved and succeeded in getting results much more quickly than would have been the case had he been forced to find out much of this information through personal experiment.

At another time, however, this same engineer was called upon to investigate the failure of a "rust-proof finish" to live up to its name. Here it was necessary to check up every operation involved in the manufacture in order to determine what caused the rusting. Having localized the cause, experiment, coupled with supplementary reading, soon pointed out the way to eliminate the trouble.

Realizing, then, the impracticability of attempting to assign any particular place for bibliographical research, but at the same time recognizing the importance of finding out what has been done and of utilizing the effort which others

have expended, let us now see what are the most important sources of information open to the investigator.

AVAILABLE BIBLIOGRAPHIES AND INDEXES

Every month hundreds of books, articles, and reports are published, any one of which may contain pertinent data relative to any particular investigation. Obviously, it is impossible for any one to read all of this mass of printed matter, and yet he must be able to refer to such articles or books as contain specific information. A great deal of the most valuable of this material is made available through the use of bibliographies and indexes which list published articles within their range.

Considering only those indexes which are most available and include articles of probable interest to the business investigator, it will be found that they fall readily into two classes:

1. Those general in scope, such as: *The Reader's Guide to Periodical Literature;* the *International Index to Periodicals;* the *United States Catalog of Books in Print* and supplementary volumes; the *Cumulative Book Index; the Agricultural Index; Public Affairs Information Service; Faxon's Annual Magazine Subject Index;* the *New York Times Index,* and others.
2. Those of a specialized character, such as the *Engineering Index;* the *Accounting Index;* the *Industrial Arts Index;* the *Index to Legal Periodicals; Cannon's Bibliography of Industrial Management; Catalog of United States Government Public Documents* and its supplements, and others.

All of the general and most of the special publications of this type may be found in any large city library, and these resources are open to practically every one. What indexes it is found necessary to use depends upon the field of activity, but it is as essential for the business man, engineer, or research man to know the bibliographies in his field and how

to use them as it is for an author to know how to use his dictionary.

But at all times it must be remembered that indexes, no matter how carefully prepared, are never entirely up to date, even at the moment of publication. Articles appear in current magazines that cannot be included. It should not be expected, therefore, that any index will furnish references to all the articles on any subject. It will, however, inform the investigator of most of those that have appeared up to the date of issuance of the index, and with this as a start, a more complete list can be prepared, if this action is deemed necessary, by referring to the monthly supplements.

Another point to bear in mind in connection with the use of any index is the necessity of understanding thoroughly what is included and how the references are classified or arranged. Only in this way can one make certain that he will be able to reach all the information that it is prepared to furnish. Even a cursory glance at the *Industrial Arts* and the *Engineering* indexes will bring out the fact that the compilers of these two indexes, even though indexing many of the same periodicals, have quite different ideas as to the proper way to classify the material in question.

For instance, if you were looking for references on "budgets" in the *Engineering Index* of 1921, you would fail to find any reference under that heading, nor any cross-references indicating where they might be found.

The average person would be justified in thinking that no articles on budgets had appeared in magazines during the year of 1921. One who was familiar with the classification, however, would turn to the main subject-heading "Industrial Management," under which the desired references on budgets are listed.

HOW TO USE BIBLIOGRAPHICAL RESEARCH EFFECTIVELY

A bibliography, and, in fact, any reference work, is a tool, and in order to get the most out of it, one must know how to

use it properly. Not only does a knowledge of the plan of classification used in the reference work you are consulting open up the way to direct references as shown above, but this knowledge enables the investigator to go beyond the apparent information given and discover other references listed under related headings which often contain pertinent information.

Another very important thing to remember is the fact that of necessity the classification of magazine articles in any index must be more or less arbitrary. A great many articles and books are general in character and can be classified under a number of different headings. Also it is becoming very frequent—even in technical periodicals—for the title to be expressed in catchy headlines rather than in terms exactly descriptive of the content matter. All this makes the task of the classifier difficult and makes misclassification or failure to include an article under its proper heading more frequent than should be the case.

The preparation of a complete list of references is largely a matter of time and research directed along the proper channels. One reference leads to another or indirectly suggests another subject-heading to be followed up. In this way a chain is created which is practically certain to bring out most of the important information published on a given subject, if one has time and patience enough.

Although the foregoing suggestions imply that the one who is seeking the information will do this bibliographical research himself, the discussion of this subject would not be complete without mentioning the librarian and urging that full use be made of his expert knowledge of published sources of information. Librarians are trained sleuths at running down references and they are usually able, from their wide experience at this work, to aid greatly in opening up the whole field of recorded experience for the benefit of the investigator.

But, often, there will not be time to prepare a complete list of references. Circumstances may be such as to require

the gathering of such information as can be secured immediately, that is to say, the material contained in the personal files of the investigator, his own library, or the company's library. In order that these sources of information may be reached as quickly as possible, it will be advisable for him to have his files or library indexed so that he may be able to obtain any desired information at once.

INDEXING UNCLASSIFIED DATA

The writer has found a very satisfactory way to index data which may be required quickly or which may not be indexed in ordinary bibliographies, through the following means. As he reads a magazine or book and notes certain pertinent information or illustrations bearing on those subjects in which he makes a specialty, he makes out a 3- by 5-inch card showing the subject, title, author, and reference. These cards are then filed alphabetically, according to the subject. Through this means he is able to supplement the list of references which it is possible to obtain from the regular sources.

In developing one's own reference data, particular attention must be given to the selection of subject-headings, the frequent use of cross-references, and the consistent classification of data under the same headings every time. For practical purposes in indexing special data along management lines, the subject-headings in the *Industrial Arts Index* are very useful.

Assuming, then, that through every possible resource an adequate list of references bearing on the subject has been obtained, inspection of this list will show that the references fall into certain classes, some of which can be consulted in local libraries and others which are not so readily available.

The references which in the main are found in local libraries usually are contained in books, pamphlets and reports, or in periodicals, trade papers, bulletins, and so forth,

having a general circulation. Books usually contain information on a given subject as of date of publication, which information varies from the highly specialized and detailed treatment in a technical book to the broad general treatment in a business book. Such sources of information, especially the former, are indispensable in getting a thorough, fundamental knowledge of the subject.

In this classification must also be included those compendiums of information such as the *Encyclopedia Britannica*, the *Americana*, the *New International Encyclopedia*, and so forth, which contain vast amounts of useful information on all sorts of subjects. Here also belong the special works and handbooks such as the *Harvard Business Reports*, Kent's *Mechanical Engineer's Pocket-Book*, *Management's Handbook*, *Accountant's Handbook*, Hall's *Handbook of Sales Management* and *Advertising Handbooks*, and other manuals of similar type with their thousands of formulas and data relative to their field.

Of particular importance as a source of recorded business information are the *Harvard Business Reports*, compiled by the Graduate School of Business Administration of Harvard University. These Reports will eventually comprise a series of well over 100 volumes and are a veritable mine of standard business precedents and a guide to current business practice.

The list of such reference works is never complete, but others with which the investigator should be familiar are: Ayres' *Directory of American Newspapers and Magazines;* Thomas' *Register of American Manufacturers;* Kelly's *Directory of Merchants, Manufacturers, and Shippers of the World;* Moody's and Poors' *Manuals*. These and other reference works of similar character are available for consultation during library hours in most large city libraries.

The other class of published information which is available in the average library is that found in periodicals, trade papers, and bulletins, of which current issues may be found in the reading-room, and back issues bound and kept on

the reference shelves. These magazines are especially valuable for the detailed, specific, and up-to-date information which is contained in them.

Every trade and industry has its trade paper and some of the more important have a number which compete with one another to see which can publish the most useful information. The files of periodicals such as *Factory,* the *American Machinist, Iron Age, Industrial Management,* and so forth, are rich storehouses of data on subjects within their special field. The more important of these periodicals are listed in the front section of the *Industrial Arts Index,* in the magazine *Class,* and in Ayres' *Newspaper Manual.*

SOURCES OF SPECIALIZED DATA

Rich and varied as are the resources above mentioned, they by no means constitute the only published information available to the investigator. They, however, include the type of publications found in the ordinary library. But there is a large and ever-increasing kind of information in the form of special reports, monographs, bulletins, and so forth, which are issued by the public, private, and semipublic agencies, sometimes for general circulation, but most often only for the use of their members or clients. The following classification of these sources of information will demonstrate not only the varied character of the data available through them, but also point out the advisability, for the investigator, of knowing what services of this type are available to him, and of using them to the utmost.

1. *Trade Associations.* Every important line of business and industrial group has its trade association. Many of these maintain research departments and distribute among their members information, statistics, and so forth, of vital significance to the business. The United States Department of Commerce has recently issued a report on *Trade Association Activities,* which contains a list of these associations and describes the constructive work which they are doing.

2. *Chambers of Commerce.* Most cities of any size, especially industrial or business centers, have chambers of commerce, which gather information for the use of local industries or to show outside concerns the desirability of locating in their city. The Chamber of Commerce of the United States has published a number of reports of great value which may be obtained by any interested party by addressing the Secretary, at Washington, D. C.

3. *Technical Societies.* More and more it is becoming the custom of business men and engineers who are engaged in specialized fields of endeavor to form groups composed of those having similar interests. In the same manner as trade associations, these societies often support a considerable amount of original research in addition to providing through their meetings and their bulletins the opportunity for their members to describe individual researches of interest to all.

For instance, the *Bulletin of the Taylor Society* is a storehouse of valuable information along management lines. *Mechanical Engineering,* the monthly journal of the American Society of Mechanical Engineers, and the transactions of the various societies, contain full reports of the papers delivered before their conventions, together with the discussion which they provoked. When it is remembered that Taylor's *Art of Cutting Metals, Shop Management,* and many other epoch-making papers giving the full account of important researches, appeared in this form long before they were available or even known to the general public, the desirability of keeping in touch with this source of reliable information becomes apparent. A list of the most important technical societies distributing data within their field is given in the front section of the *Industrial Arts Index.*

4. *Governmental Bureaus.* Most of the federal departments and many state and municipal bureaus issue reports covering their work or describing researches within their field which seem to have special significance. No complete list of these agencies is possible, as with the ever-increasing

use of scientific investigation as a basis for action, new commissions, bureaus, and so forth, are being formed all the time for the purpose of gathering information to be used later in considering certain legislation. The most important of these, however, are listed in the Public Affairs Information Service. Some of these commissions have done very significant work, as, for example, the Congressional Joint Commission of Agricultural Inquiry, which has published a voluminous report on the cost of distribution.

But the most important sources of information under this classification are the governmental departments, especially the Department of Agriculture, the Department of the Interior, the Bureau of Mines, the Geological Survey, the Treasury Department, the Commission of Internal Revenue, the Department of Commerce, the Federal Trade Commission, the Bureau of Foreign and Domestic Commerce, and so forth. The reports issued by these departments may be obtained free in many cases, and in others for the payment of a small fee. The superintendent of Documents, Washington, D. C., will furnish information regarding any report which has been issued in the past by any governmental department. Any one desiring can have his name placed on the mailing list of the department, and will thus receive announcements of forthcoming reports and surveys.

One governmental publication which should be known by every business man is the *Statistical Abstract of the United States*. This is a veritable mine, containing enormous amounts of information regarding the industries of this country. The data are presented in an extremely simple style and the book is so thoroughly indexed and cross-indexed that one can consult it readily.

5. *Private Research Agencies and Departments of Business Concerns*. Without attempting to make anything like a complete list of the agencies of this character engaged in special research and publishing the results of their work, the following classification is suggestive of the scope and the

value of the information which it is possible to obtain from these sources:

(*a*) *Statistical services,* such as Harvard Economic Service; Babson's United Business Service; Bankers' Economic Service; Brookmier's Economic Service; Standard Statistical Service; National Industrial Conference Board; National Bureau of Economic Research; and so forth. All of these agencies maintain staffs of research men engaged in gathering information which has a bearing on business, and no business man or engineer can afford to overlook these resources. True, they are by no means infallible, but taken by and large they furnish extremely accurate and pertinent information in such form that it can be used by the average business man.

(*b*) *Research departments of industrial and commercial concerns.* These departments may be maintained by the individual industry or by a group of industries, as, for example, the laboratory of the National Electric Light Association at Nela Park and the research departments of such concerns as the American Telephone and Telegraph Company, Swift and Company, General Motors Company, and so forth. Banks and financial houses are more and more realizing the value of research, and many of them, as, for instance, the National City Bank of New York and the Continental and Commercial National Bank of Chicago, undertake very broad types of surveys. The larger public service corporations, insurance companies, advertising agencies, and so forth, maintain research departments, and a considerable amount of pertinent information can be secured from these sources when one knows who is engaged in the study of the problems in which he is interested, and this can easily be ascertained through correspondence. Special pamphlets and reports issued from time to time by these agencies are indexed in the Public Affairs Information Service.

(*c*) *Educational institutions.* Outstanding examples of

valuable sources of information coming under this class are, the Bureau of Business Research, Graduate School of Business Administration of Harvard University, The Institute for Research in Land Economics and Public Utilities at Northwestern University, the Mellon Institute, and so on. The reports showing the result of their research work are often published for general circulation and can be located through the indexes previously mentioned.

(*d*) *Newspapers, periodicals, and trade papers.* Many of these also undertake research work both for the benefit of their subscribers or their advertisers, the results of which are sometimes published but in all cases are available for interested parties. Examples are the *Chicago Tribune's* study of the Chicago market; *Successful Farming's* study of the agricultural market; the Curtis Publishing Company's survey of the national market.

The amount of specialized information of this kind which is available for the use of the business man or the investigator in any field is increasing every year, and touches every type of business and industry. Through reading the advertising pages of the leading general and technical magazines one can keep in touch with the type of information of this character which is available. With the expenditure of a little time in correspondence and a few stamps he can secure a considerable quantity of specialized information which may at any time be of great service to him.

Much of the foregoing information is available, however, only to members of various associations, or the clients of private research agencies. Hence it is highly desirable that the business man or engineer desiring to keep abreast with the times should be a member of such societies and associations as specialize in his own field of activity. However, many of the larger libraries make a special effort to secure as many as possible of these reports, and fairly complete collections can be found on the shelves of the Engineering Society's library, of New York; the John Crerar Library, of

Chicago; the Newark, New Jersey, public library, and others.

UTILIZING RESOURCES TO THE UTMOST

Before concluding the discussion on sources of published information, it may be desirable to make one further suggestion. It is a natural tendency for every one engaged in investigational work to choose a particular field to which special attention will be given. One individual may specialize in power plant practice, another in office management, and so on, through the various divisions of business activity.

It is only natural that one should read extensively along the lines of his special interest, but he will not have the time, as a rule, to read widely along other lines, even though related. As all business is subject to the same basic laws, and as it is common practice to borrow profitable ideas from one business and use them in another, even though seemingly of an entirely different type, it is advisable for him to keep in touch with the most important discoveries in other fields. This may be done through reading a current digest, such as *The Business Digest* or the *Industrial Digest*, and also the summaries published in many of the trade periodicals.

These digests tell him of important articles published in other periodicals, as well as announce forthcoming books and pamphlets. Articles or books which seem from the summary given in the digest to contain information particularly interesting can be noted and read when opportunity offers. Others may be mentally noted or indexed according to the plan outlined in the previous part of this chapter. Thus the investigator builds up in a short time a very comprehensive knowledge of business progress.

OTHER SOURCES OF RECORDED EXPERIENCE

In the investigation of a business problem, however, one is almost never confined to published information in order to

obtain the written experience of others. Departmental records kept by the business itself contain vital information which often represents the logical starting point for one's work. Even when this is not the case, the background which is furnished by these records is needed in order that the problem may be properly analyzed and an effective plan prepared for its attack.

The extent and character of these records depend entirely upon the business itself, and, as a consequence, no extended discussion of these sources of information is possible, except to call attention to them in a general way. In practically every business, however, records are kept covering sales, production, and costs, and these will serve as an example to show the character of information which may be expected from the internal records of the business and how this information may be secured.

Sales records are valuable sources of information regarding the demand for the product, and every business enterprise sells some sort of a product, whether it be a commodity or a service. In most cases the records showing volume of sales will be classified to a certain extent, although this may not have been done as thoroughly as might be desirable. Where the sales records do not differentiate the products by class or type, it is usually possible to obtain sufficiently accurate figures from other sources such as production, storeroom, and warehouse records, which will show the approximate sales of each class of product.

Knowing, then, the sales by classes or types of product, it becomes possible to estimate the probable future demand, and this information may be of the greatest importance in planning for efficient purchasing in a merchandising establishment or production in a factory. Another important result obtained from the proper analysis of sales records is the reduction or elimination of obsolete parts or products.

One medium-sized manufacturing establishment in St. Louis was having great difficulty in securing sufficient volume of production to meet the requirements of the sales

department, notwithstanding the fact that an abnormally large inventory was being carried. Believing that an improved production-control system was required, an industrial engineer was employed for this purpose.

Beginning his work with an analysis of the sales records and properly classifying the data contained therein, he found that not only was there an excessively large stock already on hand of slow-moving parts and products, but that production schedules were still being issued to make up more of these parts. Following his recommendations, all obsolete parts and products were disposed of, with the exception of a reasonable stock kept for repair purposes. The stock carried of slow-moving lines was reduced to a minimum, and production schedules for all such parts were withdrawn from the shop. Resulting from this action alone a saving of $40,000 was effected during the first year.

The value of knowledge as to volume of sales in the planning of purchases in mercantile establishments or the preparing of advertising and sales campaigns, catalogs, and so forth, is obvious, but enough has been mentioned to show what valuable resources may be found in the sales records of any business.

Production records are also important resources for the investigator, and in many cases they represent a point from which personal observational work must start, indicating as they do the points where insufficient volume of production is being secured. Here, too, there must be accurate classification of the output records so that the information contained in them will be comparable. Unfortunately, in many concerns, particularly in the office or clerical departments, such accurate records are not maintained, or when they are kept they are so carelessly prepared as to be of little or no value.

When such is the case an important starting step in any investigation along production lines will be to establish accurate, comparable records which will show the relative proficiency of the workers or departments. After these have

been kept for some time, analysis will show many places where betterments can be obtained, resulting in increased volume of output, elimination of waste, decreasing cost, and so forth.

The establishment of such comparable records is relatively simple in factory, office, or sales departments where individuals are working continuously on the same class of work. Where workers are engaged at different tasks during the day, as, for example, general clerical work, it has been thought impracticable to attempt individual output, and the effort is made through the supervision alone to secure a reasonable volume of work. Unfortunately, the lack of standards results in the workers having no incentive to do more than simply enough to get by. But even the most varied work can be measured through the simple expedient of reducing the different kinds of work to common denominator, usually of time, and of expressing the output in these terms.

Of equal importance to sales and production records in most investigations are the records showing costs, and these should be subjected to close scrutiny and analysis. The information obtainable from good cost records is almost unlimited. Among the important things they will show the investigator are unit costs of products, thus pointing out profitable points of attack in order to eliminate waste or reduce costs.

They will also show excessive expenditures, leading to an analysis of these, in order to promote greater efficiency, and thus reduce expenditures. Use of equipment, efficiency of labor, excessive scrapping of material, and so forth, are important avenues of investigation that a careful study of the cost records will point out.

An example in point is taken from the experience of the Dennison Manufacturing Company:

A study of the material in process revealed 12 causes of the waste. To help to remove them, current daily quantitative reports now point out the proportion of waste due to each cause and to each employee. The waste on this product, which was 12.5%

in 1918 and 10% in 1919, has now dropped to 5.55%. The money saved every month runs into four figures.

This saving was not possible without first securing the cooperation of the employees. In fact, the first study made by the research man proved not only costly, but of little value. The research man had done a good job, but he had to stand over one machine for several weeks at a time; then when he got through, it was discovered that the study of that machine did not yield significant lessons about the action of the other machines, each of which varied slightly from the others owing to different colors of dye, different operators, and the variation of the material itself.

In order to get detailed records from all the machines would take too many research men. But the product of the first machine goes to individual operators of the cutting machines—the ones who necessarily inspect the material from the first machines and lay aside all material that is not of good quality.

When the work of keeping records was turned over to these machine operators themselves, however, the studies at once became accurate and significant. These complete records are of such great value that they are now collated and tabulated as soon as they are received.

Sales, production, and cost records by no means exhaust the information in the form of recorded experience which is available to the investigator from the records of his own business. Without attempting further discussion of this point, sufficient has been said to indicate clearly that the investigator has in these records valuable sources of information which can be used to advantage in any research work he is undertaking.

In conclusion, then, the business man, engineer, or scientist who desires to make a thorough study of any problem will find it greatly to his advantage and will save himself hours of labor by finding out what others have done along the same subject. The chief resources for the gathering of recorded experience have been mentioned in this chapter. The use of them will lead to other resources which space does not allow to give in more detail. The main thing is to make sure that as much as possible of the necessary recorded information of the subject is ascertained.

IX

INTERVIEWS

Tapping the resources of unrecorded experience through interviews. Advantages of the interview: (1) direct and economical; (2) the only way to secure certain types of information; (3) flexible. Limitations of the interview. How to use the interview effectively: (1) planning the interview; (2) selecting the parties to be interviewed; (3) character of the entree; (4) personality of the interviewer. Some helpful rules.

There is an untold wealth of information about any subject which has never been put into writing and which, therefore, cannot be reached by bibliographical research no matter how extended that may be. The only way the investigator can tap this reservoir is through the medium of interviews and questionnaires. If persons in the immediate vicinity possess the desired information, it can be obtained by talking with them or, in other words, through an interview.

If, on the other hand, the persons are located at points distant from the place where the investigator is working and he desires to find out what they know about the subject, his only recourse is through correspondence, and the questionnaire is the formal method of asking for information in this way.

Besides the foregoing distinction, there is another which is even more important. In the case of the interview, the controlling factor which influences its success or failure is the reaction of the personalities involved. In the questionnaire, however, everything depends on the skill with which the inquiries are presented.

Interviews are one of the most common means of securing information, and they are in frequent use by every one. From conversations with customers, salesmen, workmen, or colleagues, the executive ascertains facts and opinions

which materially influence decisions or modify the direction which he will take in his efforts to solve a problem. In fact, every reason which prompts him to find out what has been published on a subject should lead him to make an equally careful study of the field of unrecorded experience.

The interview then takes its place as an important means of gathering the facts within a distinct field. Naturally, it has certain advantages and disadvantages, and these will now be considered.

ADVANTAGES OF THE INTERVIEW

The principal advantages of the interview may be summed up as follows:

1. It is direct and economical;
2. It is the only way certain types of information can be secured;
3. It is flexible, permitting of maximum variation in the direction of inquiry.

The interview, in many cases, is almost as direct, and when care has been taken in the selection of the persons interviewed, is quite as trustworthy a means of getting the facts as personal observation. Every executive realizes this, and when a particularly difficult problem comes up on which he does not have all the facts, he calls in a subordinate or consultant who has the required information and gets the facts from him before making his decision.

In like manner, the experienced investigator relies a great deal on the interview. At the beginning of his work he often finds it advantageous to talk over the problem with selected individuals who have expert knowledge of the subject. The information thus secured, coupled with his own analysis, helps him plan how he is going to attack the problem. Thus he conserves time and effort and avoids stumbling into unprofitable lines of inquiry at the start.

As he continues his work, he constantly uses the interview for the purpose of supplementing his personal obser-

vation, and frequently of checking his own experience or ideas which he has obtained from other sources. In other words, he uses this method of getting information in much the same way as does a physician, when he asks a patient to describe how he feels and what he thinks is the matter with him. Not that he believes everything that the patient says, but he combines the facts thus secured with other facts personally observed and makes a diagnosis of the case.

But the directness and ease with which information can be secured through this means often creates a serious handicap. Especially is this true in the case of an inexperienced investigator. Lack of sufficient knowledge of the subject, or inability to distinguish between opinions and facts, often leads him into difficulties when he relies too much on what others tell him.

When investigating production problems in shop or office, he will find heads of departments only too ready to tell him what is wrong—with another department. Into his ear will be poured a miscellaneous collection of opinions, theories, quasi-facts, and suggestions. If he does not maintain constant control over his mental processes, many of these will be assigned undue significance and will often influence his work disastrously.

But these same opinions may prove of great value to him when they are accepted at their true value and subjected to careful scrutiny and examination. The solution to many a problem can be traced to an offhand remark which has suggested a new angle of approach.

A wholesale grocery concern was receiving numerous complaints stating that its peanut butter contained sand. As a new grinder had been installed only recently, and as the peanuts were cleaned carefully before being ground, the management was quite at a loss to account for the complaints.

One of the assistant chemists was instructed to find out what caused the trouble. His first step was to check up the cleaning of the peanuts, at the same time taking daily sam-

ples of the product. His check-up convinced him that no foreign matters were fed in with the peanuts, but his samples showed that while in some there were slight traces of grit, in others there were no traces at all.

This puzzled him greatly, as he could think of no way in which dirt could get into the machine. While he was in the department one day, he overheard the repairman complain about "the way that grinder wore out burrs." This offhand remark started him on a new line of attack. He found that the grinder did wear out burrs quite rapidly, and that this was the source of the grit. It was then but a simple matter to get harder burrs and make a slight readjustment of the machine, which resulted in eliminating the difficulty.

Perhaps one of the greatest advantages of the interview is due to the fact that through this means information may be obtained which it is impossible to secure in any other way. This includes details regarding matters which, though not of sufficient value to be published, are of particular value to the immediate problem. Limitations of space usually forbid of including in any article or book all the details showing how the conclusions were established, and yet to an investigator certain of these details may at times be essential, in order to enable him to make real use of the conclusions.

Then, too, ideas or practices, even when of transcendant importance, are nearly always available through the medium of conversation before they are written up by the originators. For more than 20 years Taylor worked on the problem of finding out the proper methods of cutting metal. Even after he had completed his experiments it was many years before they were published and available for general use. However, during all that time the data were at hand and were used by those who had the opportunity to get them personally from Taylor.

Still more of the valuable information never does get reduced to writing. In every business there are men with

fertile minds who either lack confidence in themselves, are too indolent, or do not have the ability to express their ideas clearly in writing. To one who possesses their confidence they will talk freely, and often through this means ideas of great value are brought to light which otherwise would remain unknown.

It is here that the interview has a great advantage over the questionnaire. People who will not take the trouble to answer the shortest questionnaire will talk, and in that way give the desired information. Then, too, most people will give out information freely in conversation, owing to the informality of the occasion, which they would not think of writing down on paper. Especially is this true of matters of internal policy or routine.

And this leads to one of the greatest weaknesses of the interview as a means of getting information—the inaccurate and offhand character of many of the statements which are made in conversation. Few people weigh their words with anything like the care with which they consider a statement which they expect to go into print. As a consequence, the investigator must be at all times on the lookout for exaggerations or other inaccuracies. This makes it all the more necessary that he carefully test the data secured in this way before incorporating them into his work.

The interview has almost as great flexibility as personal observation. It is bounded only by the personalities involved, and if, as should be the case, the interviewer tactfully controls the interview, the direction of inquiry may be changed whenever circumstances make this desirable. Not so with bibliographical research or questionnaires, for in both cases the printed word establishes definite channels which do not allow deviation.

This flexibility has its disadvantages also, and one of the most important of these is the opportunity it affords for extending the work along unprofitable lines. But this is a disadvantage by no means peculiar to the interview. At every stage of investigational work the danger ever exists

that the investigator will lose his perspective and run off on a tangent. Only by constantly checking up the work with the objective and the plan, as recommended in an earlier section, can this danger be avoided.

Last, but by no means least in value, the interview itself is an excellent stimulation to all parties involved. It is a well-known fact that nothing is quite so good at bringing out ideas as discussion, where each of the parties has something to contribute. The results accruing from the joint effort will greatly exceed the sum total of the results which would be secured from the same individuals when each is working separately.

"In a multitude of minds there is wisdom," runs an ancient saying. The contact of minds, a hint here, a suggestion there, leads to the birth of ideas which might not have been conceived but for the stimulation of the discussion. This fact is one of the basic reasons back of the practice of holding conferences on important matters.

LIMITATIONS OF THE INTERVIEW

At the same time that these advantages are admitted, it must be realized, also, that the usefulness of the interview is restricted to a considerable extent by limitations of time, space, and expense.

It is obvious that this means of gathering information requires quite a little time, especially when there are many persons who must be seen. If the desired information must be secured quickly, the number of individuals who can be consulted is correspondingly lessened or the interviewing of many of the persons must be entrusted to agents.

In the average investigation there is usually only sufficient time for a very limited use of the interview. It is only in market surveys or investigations of far-reaching scope that time enough is available to consult a considerable number of those who might be able to furnish valuable data. In such cases the employment of field men is a neces-

sity, in order that desired information may be secured in time. This makes it necessary to set up definite measures of control, to assure that dependable information will be obtained. Even then the opportunity for error is greatly increased.

Another obvious fact is that by its very nature the interview is limited in its use to a particular locality. When it becomes necessary to secure information from persons residing at a distance, reliance must be had either in agents or in questionnaires. As in the case of time, this limitation is most applicable to the average type of investigations and affects less those of larger scope.

At all times the use of the interview is limited by the factor of cost. Especially is this an element to be considered when results are demanded within a limited time. The employment of a number of individuals to secure the information not only adds directly to the cost, but in the added opportunity afforded for error and waste brings about an expense that may easily exceed the value of the data secured.

In the average investigation these limitations naturally restrict the use of the interview to a few carefully selected individuals, but do not detract in any way from the importance of the means of gathering the facts. As has been stated, these limitations affect most investigations of large scope, where, due to the expense involved in making such surveys, the proper use of this tool becomes vital. In all cases, therefore, these limitations demand that the investigator making use of this method of getting the facts should know how to conduct an interview properly, and this is, therefore, the next subject to be discussed.

HOW TO USE THE INTERVIEW EFFECTIVELY

No matter whether the investigator personally makes use of this means of gathering information on the subject or delegates it to others, the successful acquisition of the de-

sired facts is dependent on how well the following have been considered:

1. The planning of the interview;
2. The selection of the parties to be interviewed;
3. The character of the entree;
4. Th personality of the interviewer.

1. *Planning the Interview.* The same reasons which made it advisable to plan carefully in advance the scope and procedure to be followed in making the investigation, make it essential to plan the interview carefully before it is attempted. When one goes to persons for information without a clear understanding of what is needed, the chances of gaining adequate or pertinent information are very remote. In such cases the interview is bound to be aimless, wasting valuable time of all parties involved. When, however, the investigator has a definite idea of what he wants to find out, he is able to proceed directly to the heart of the matter, gaining the desired information at a great saving of time and effort.

Having decided upon the type of information desired, it is a good plan to determine on the questions to be asked and, so far as possible, the way in which these questions will be worded. It is not the easiest thing in the world to ask questions which do not permit of misunderstanding. Their proper phrasing should not be left, therefore, to the inspiration of the moment. They should be carefully prepared in advance, to insure that they ask for exactly what is wanted, are definite and to the point, presented in proper sequence, are not too numerous, and do not include any that are unnecessary. Only by careful planning can this desirable condition be secured.

When a considerable variety of information is desired and there is a possibility that in the stress of the occasion certain questions will be omitted, it is a good plan to prepare a list of the main points to be considered and to check off on this list each point discussed. In still more important cases, where much depends on the exact wording of

both questions and answers, it is often necessary to read the questions and write down the answers as given.

But neither of the foregoing plans should be resorted to except as an absolute necessity. One of the great advantages of the interview is its informality, and this is entirely lost when written questions are introduced or written notes taken by the interviewer. When this occurs, the person being interviewed begins to weigh and consider very carefully what he says, because he knows that he may be quoted. The spontaneous pouring out of comments, ideas, and suggestions ceases. He becomes overcautious and, through fear of being quoted, refuses to make direct answers in many cases where he would otherwise not hesitate.

2. *Selection of the Parties to Be Interviewed.* In most cases there are a number of persons who can furnish the desired information, and, therefore, the selection of the most advisable person to interview becomes a matter of considerable importance. Foresight and astuteness in picking out those who possess expert knowledge on the subject often enables the desired information to be secured without the necessity of spending a lot of time in this way.

In making market surveys and extensive investigations of similar type, the problem of selection takes another form. To interview all the grocers in a large city would not only take a long time, but would cost so much that it probably would not be a profitable undertaking. The best way is to select a certain number who are representative of the whole; that is, the list to be interviewed should contain grocers doing a large, medium, and small business (the number of each class being in proportion to the total number of grocers in the city). Care must be taken to see that a proportionate number will be selected from each buying center and to meet any other classifications which the requirements of the problem make desirable.

In one large city it has been demonstrated that the data secured from interviewing 100 selected grocers, of which 20 were located in the central part of the city, 25 on the

north side, 25 on the south side, and 30 on the west side, were just as accurate as though every one of the several thousand of the grocers in that city had been interviewed separately.

There is an element of danger in this process of selection in both cases. On the one hand, while the selection of a certain number of experts to be interviewed on a technical question will be productive of reliable information, the same condition is not equally true when the data required are of a general rather than a technical character; for instance, the composite opinion of the 10 leading golfers would be almost decisive as to the merits or demerits of a special shaped club. On the other hand, the unanimous opinion of 10 of the most carefully selected men would prove nothing regarding the popularity of a shaving cream.

In investigations, then, involving human likes and dislikes, opinions, and so forth, selection must be based rather upon number, care being taken at the same time to have this number include a representative number of each class affected.

3. *Character of the Entree.* The interview having been planned and the parties to be interviewed selected, obviously the next factor of importance becomes the entree; that is, the actual bringing about of the contact between the interviewer and the person to be interviewed. Naturally, if the investigator is personally known to the person being interviewed, has been introduced by a mutual acquaintance, or has unquestioned credentials, he undertakes his work under the most favorable conditions. If he does not have any of these, he undertakes the interview under very unfavorable circumstances and, in fact, may frequently not even be able to get to talk with the desired person. In fact, it may be said that the lack of an effective entree renders it practically impossible to get information at times, and in all cases renders it difficult.

In a broader way, the lack of a proper introduction to

the personnel of a plant or office is often a fundamental cause underlying the failure of the engineer to secure the results desired from his work. By introduction in this case is not meant the formal meeting of executives with whom he must work, although this is highly desirable when they are not too numerous.

Rather, it refers to the general attitude which the management assumes toward the engineer and his work. If the feeling is "here is a 'wise guy' who is going to show us how to do our work," failure is invited from the beginning. When the attitude is one of desire to be helped, and the spirit of cooperation and moral backing of the management are present, then, all other factors being equal, the engineer's work will probably be successful.

Human nature is much the same everywhere. We are naturally clannish, and the stranger has a hard row to hoe. In one large plant where a statistical department is maintained for the purpose of doing research work, the writer happened to be conversing with the head of one of the departments when a young man came up and asked for certain information. "What do you want to know for?" he was asked. The young man stated from what department he had been sent, but the executive was obdurate and refused to give out the information without proper authority.

If this young man had been supplied with proper credentials or introduced to the department heads with whom he had occasion to deal, this difficulty would have been avoided. The department heads naturally objected to being asked for information by Tom, Dick, or Harry, and the feeling became so bad in this particular plant that the statistical department was reorganized and put under different management.

4. *Personality of the Interviewer.* Once the entree is made, the successful securing of information becomes largely a matter of salesmanship, and the personality of the interviewer becomes the controlling factor.

The interviewer must first of all sell himself to the per-

son being interviewed, and must then sell the idea of furnishing the desired information. If this is effectively done, the way is paved for securing information of real value. To secure desired information from others successfully, the investigator must possess to a marked degree certain of the qualifications already discussed in Chapter III, "The Qualifications of the Investigator." A noticeable lacking in this respect, while not fatal to the successful gathering of information through other channels, does make it difficult, and at times impossible, for him to get desired information through conversation with others.

The first of these essential requirements is tact. Combined with this must be a considerable amount of diplomacy. The successful interviewer is a sympathetic listener, encouraging the person with whom he is talking to speak freely of the matters on which he desires information. He must be capable of inspiring confidence and a desire to cooperate. When opposition is encountered, as is often the case, he must be capable of disarming it and of getting the information in one way or another without arousing resentment.

Another requirement is that of impartiality. The purpose is to collect the facts, not to expound his own ideas. Consequently, he must be careful to avoid phrasing his questions in such a way as to encourage a particular reply. A common way many people have of asking a question is, "You don't know anything about this, do you?" or, "You aren't finding that method very successful, are you?" Needless to say, this is not only an ineffective method of asking a question, but is likely to encourage an answer which may be entirely incorrect. That questions should be worded so that no preference is indicated either by word or action seems so obvious that special emphasis should not be required. However, one's personal opinions and desires have such an unconscious way of showing themselves that unless the interviewer is constantly on the alert, he will fall into the error of influencing the replies. Especially is this

the case when the interviewer possesses a broader knowledge of the subject than the person interviewed.

Closely associated with the foregoing is the quality of reliability. The interviewer must, in justice to himself, record the exact information he secures, precisely as it is given, without coloring it by his own opinions. But it is when others have to be employed for the purpose of interviewing that this quality of reliability assumes its greatest importance. Great care must be taken to select only those who can be trusted to report faithfully what they are told. The character and strength of their prejudices should be known so that their work can be tested in order to bring out any glaring inaccuracies.

Besides this, in order to make sure of the accuracy of conclusions drawn from a number of interviews reported by different individuals, some means of checking the information must be developed.

Another general qualification of the investigator which assumes special prominence in interviews is the possession of a good memory. While, as brought out before, it is frequently desirable to have certain set questions to be asked, and even at times it is possible to present these in writing and get the replies from the one interviewed, yet, in most cases, the sight of a pencil and the act of taking notes exercises a restraining influence on the giving of information. The interviewer must depend on his memory to store away the valuable information which has been imparted to him until such time as he has an opportunity to write it down and thus get it in permanent form.

But, above all, the interviewer must know his subject thoroughly, or at least have clearly in mind what information is desired. Unless this is the case it is impossible for him to ask intelligent questions or to direct the interview along the most profitable lines. An interview is a game in which one party is matching his wits, consciously or unconsciously, against the other. The most elaborate set of questions will not be as certain of securing reliable infor-

mation as a definite knowledge of what is wanted, which enables the interviewer to steer the conversation along the right channels. Nearly every executive is on the alert for new ideas. When, therefore, he recognizes the interviewer as a master of his subject, he gladly gives his time, expecting something profitable to develop as an outgrowth.

In this connection it may be desirable to quote some rules which are in use on one of the leading newspapers. Although prepared for the guidance of reporters, these rules include many points of value for engineers:[1]

1. Make a definite appointment with the man to be interviewed and keep it to the minute.
2. Learn as much as possible about the man to be interviewed before you approach him.
3. Know the subject of the interview. The best interviewer is one with whom the interviewed can talk on something like equal terms and not find it necessary to go into too much explanatory detail.
4. Do not expect the interviewed to volunteer information. Take the lead in conducting the interview: that is your job.
5. Frame in advance some pertinent questions that get at the heart of the subject.
6. Do only as much talking as is necessary to keep your subject talking.
7. Keep some leading questions in reserve with which to bring the interview back to its subject-matter if the interviewed becomes vague in his discussion.
8. Observe the courtesies of your position—don't argue—don't contradict—don't insist. Discuss the points that require some comment in order to bring out their meaning or to bring out the other side of the question or to keep the interview moving.
9. If the information quoted is of an important character or involves many statistical references, figures, mathematical formulas, or other exact statements requiring careful checking up, it is generally best to submit the interview for approval before publishing it.
10. Do not let the interview drag. Bring it to a close while the matter still holds interest."

[1]Swetland, H. M., *Industrial Publishing*, p. 21.

SUMMARY

From this survey of the interview as a means of collecting the facts, it will be seen that it plays an essential part in gathering information in certain types of investigations, and a very important part in all others. It is necessary, therefore, for the investigator, when using this tool, to have clearly in mind the essentials of an effective interview, which are:

1. It must be carefully planned so that it will bring out the desired information.
2. Careful selection must be made of the persons to be interviewed.
3. The interview itself should be conducted under circumstances as advantageous as possible.
4. The investigator, or the one conducting the interview, must exercise all his powers of tact, diplomacy, persuasion, and affability to the utmost.

X

QUESTIONNAIRES

Tapping resources of unrecorded experience through correspondence. Use of informal methods. Formal method—the questionnaire. Advantages of the questionnaire. Disadvantages of the questionnaire. How to secure satisfactory results from questionnaires. Rules for the preparation of the questionnaire. Enlisting the recipient's interest. Distributing the questionnaire. Handling the returns.

In discussing the different methods of collecting the facts, it has no doubt been noted that each is especially adapted to tap certain sources of information. Primary, or first-hand, data can only be secured through personal observation and experiment. Secondary sources, preserving the experience of others, can be reached in three ways. If the information has been put in written form, bibliographic research is the obvious method to use. If unrecorded and the persons having the desired information are close by, the interview is the logical method.

When, however, the persons possessing the required information are at distant points, the only way it can be secured is by correspondence. The simplest and most usual way this is done is by means of the personal letter of inquiry, sent to friends and fellow-workers known to possess information on the subject. Because of its personal character, extremely valuable data are often secured in this way, but its field of usefulness is greatly restricted. With this brief discussion we shall pass on to the formal method of writing for information, which is known as the questionnaire.

The questionnaire consists of a series of questions which, when properly answered by the person to whom it is sent, will furnish the sender with certain desired information. It is formal and impersonal, and is sent regardless of whether or not the sender knows personally the person to whom it

is sent. A letter usually accompanies it, designed to interest the recipient in furnishing the desired information.

The use of the questionnaire for making extensive collection of information from wide-spread sources has increased greatly in the past few years. Although subject to certain drawbacks, which will be discussed later, it is a very orderly method of getting specific information and, when used properly, has a large field of usefulness.

ADVANTAGES OF THE QUESTIONNAIRE

The chief advantages of the questionnaire are range and economy. In range it has no limitations. A questionnaire can be sent to any one served by the mails. This makes it possible to get specific information from sources which can be reached in no other way.

The questionnaire is economical inasmuch as the cost includes only that of preparation, mailing, and handling of replies. If, therefore, a sufficient number of adequate replies are received, it is much more economical than the personal interview. Still more important, it saves the time of the person from whom the information is desired, since he is able to fill out the answers at any time convenient to him.

On the other hand, the questionnaire has certain disadvantages which limit its field of usefulness considerably. The most important of these are:

1. The difficulty of securing replies;
2. The inadequacy of the replies.

The number of people who will answer a questionnaire is relatively small, even though it may be decidedly in their own interest to furnish the desired information. No general figures can be given, as the percentage of replies varies with the kind of questionnaire and the class of people to whom it is sent.

A return of between 8% and 10% is considered good for those types of questionnaires that are sent out to dealers,

consumers, and so forth, as a part of a market survey. In the case of special questionnaires sent to scientists, technicians, engineers, and so forth, a larger percentage of replies is often obtained. The writer, in a number of cases of this kind, has had as high as 70% returns and knows of cases where even higher percentages have been received.

Even when sufficient returns are received, it frequently happens that those who answer are not representative and that, consequently, the data received do not furnish a true picture of conditions. One of the leading trade periodicals was in the habit of getting information pertaining to the industry from its subscribers. A mailing list consisting of several hundred names was used, and most of them could be relied upon to furnish the desired information.

Unfortunately, this list, while seemingly a splendid resource, did not prove as satisfactory as expected because it was composed almost entirely of men who were especially interested or possessed advanced information on the subject. Their replies, therefore, while of a certain value, did not furnish an accurate index of the industry.

As the questionnaires come in, it is often a source of considerable disappointment to note the utter inadequacy of many of the replies. Instead of giving real information, they often show a lack of comprehension or failure to even answer the question at all. "Sometimes"—"Don't know"—"Can't tell"—and qualifying phrases of various kinds are common, not to speak of the cases where the writing cannot be deciphered. From a statistical standpoint the occurrence of any of these inadequacies increases greatly the chance for error.

Then, only too often, the questionnaire does not fall into the hands of the person for whom it is intended. Some clerk may answer it from his limited knowledge and experience, and often his replies are quite different from those which would have been given by the proper executive. Careful preparation, however, discounts loss of these objections.

HOW TO SECURE SATISFACTORY RESULTS FROM QUESTIONNAIRES

While it is admitted that the difficulty of securing sufficient adequate replies is a great disadvantage, yet in many cases these results are due rather to the weakness of the questionnaire itself than to the weakness of the method. Owing to haste in preparation the questions have not been clear, are too numerous, or call for too much consideration. Naturally, but few replies are received and these are perhaps valueless. Forthwith the questionnaire as a means of gathering information is condemned.

However, the questionnaire can be used to advantage in the collection of certain kinds of facts, provided it is *carefully prepared* and *properly presented* to a *selected* mailing list.

Its inflexible character makes it necessary that in order to get satisfactory results especial consideration must be given to:

1. The determination of the content matter and the form in which the questions shall be presented;
2. The creation of a desire on the part of the recipient to answer it;
3. The distribution of the questionnaire under the most favorable conditions;
4. The provision of means for handling the returns.

THE PREPARATION OF THE QUESTIONNAIRE

The probability of success or failure from the use of the questionnaire depends, in the final analysis, upon the care with which it has been prepared. If it is inaccurate, incomplete, or likely to be misunderstood in any part, the information secured will be inadequate even though there may be 100% returns.

Not long ago the writer was discussing the value of the questionnaire with a prominent sales manager. This man was inclined to doubt whether reliable information could

be secured in this way, and, to prove his contention, cited a recent unfortunate experience. It seems that he wanted to get certain information from dealers in Michigan and he had sent out quite a long questionnaire to all dealers of a certain class. He received only about 5% returns and some of the data later proved to be entirely incorrect.

He was ready to admit, however, that the questionnaire had been "doped out," as he expressed it, rather hurriedly, and that it was not as good a job as many that he had received. In fact, on close analysis it was quite evident that no consideration had been given to the interpretation that the dealer might give to some of the questions. Averages were asked for in several instances without explaining what was to be considered in their computation. Several technical terms were used, the meanings of which were probably unknown to many of the dealers. Naturally, those who answered the questionnaire interpreted these questions in their own way and, hence, the inaccuracies.

The questionnaire was also entirely too long and asked for many things which were not really needed, but notwithstanding these facts, had reasonable care been taken in the preparation, the number of returns would have been greatly increased and in accuracy they would have tallied closely with the results obtained from an equal number of personal interviews.

RULES FOR THE PREPARATION OF QUESTIONNAIRES

This incident shows the necessity of making the questionnaire as fool-proof as is humanly possible. Too much emphasis can hardly be placed on its preparation. In making certain that its content matter will be adequate, the following rules have been found helpful:

1. Make a careful analysis of the subject in order to determine what information is essential.
2. Visualize as clearly as possible the person from whom the information is desired.

3. Make certain that only such information is requested as can be furnished by the persons to whom the questionnaire is sent.
4. Ask no questions which there is any reason to believe the recipient will object to answering.
5. Phrase all questions so that there can be no misunderstanding as to what information is desired.
6. Make it as easy as possible for the recipient to furnish the desired information.
7. Arrange the questions in logical sequence.
8. Avoid long or involved questions.
9. Phrase the questions impartially so that no indication will be given of the answer that is expected.
10. Make the questionnaire as brief as is consistent with a thorough handling of the subject.

1. *Determine what is essential.* A questionnaire in itself is a restricted form of investigation and subject to the same laws. It will be recalled how important it is to plan the investigation as a whole. It is still more important to plan carefully the content matter of the questionnaire, since the latter is a more inflexible instrument, and alterations, modifications, or explanations are impossible after it has been sent out.

The questionnaire obviously must include sufficient questions to bring out the desired information. To do this requires careful analysis of the subject from every angle. It is fairly easy to isolate the primary information which should be secured. The chief difficulty lies in determining in advance the probable subordinate issues which may develop. However, it is very important to consider what these will be so that questions can be prepared which will have for this purpose the elimination of undesirable issues and the procurement of additional information on others.

2. *Visualize the person who will reply.* The questionnaire must be constructed from two standpoints. There is the point of view of the sender, which is fully covered in the analysis just mentioned. But the recipient's point of

view must also be considered. In fact, no one can prepare an adequate questionnaire without having a very clear mental picture of the persons who have to answer it.

Unless the viewpoint of the recipient is thoroughly understood, there can be no "meeting of minds," and the results are bound to be unsatisfactory. In phrasing every question his capacity must be carefully considered.

3. *Ask only for information that he can furnish.* It is not always possible to ask for all the information which the analysis shows to be desirable. No benefit is secured from including any questions which the recipient cannot anwer from his own first-hand knowledge. Such information should be obtained through other channels of inquiry.

It is not even advisable in most cases to include questions which will call for guesses or estimates unless the nature of the investigation is such that a "guess" will be satisfactory. When accurate information, however, is desired, the inclusion of such questions is certainly not desirable.

4. *Include no objectionable questions.* Closely associated with the foregoing is the obvious rule that no questions should be asked which, it is believed, the recipient will hesitate to answer. If he feels that some questions are too personal or ask for information he considers should not be given, he not only will refuse to answer them, but will often throw the entire questionnaire aside. The formal questionnaire is not the proper way to get "inside information." When there is any doubt as to the possible reaction to any question, and yet the information is necessary, the only practical method is a skilfully conducted interview.

5. *Questions must be absolutely clear.* Every question should be worded so that it can be given but one meaning or interpretation. Nothing should be taken for granted. If the questionnaire is not clear or is phrased in a terminology unfamiliar to the recipient, either no answer at all will be given, or, if an attempt is made to reply, the answer may be incorrect.

If there is any doubt whatever as to the meaning which will be given to any word or phrase in the question, a note should be appended giving the correct meaning. In one questionnaire it was asked "What is the gross area allotted to each office worker?" No explanation was given as to what was meant by the term "gross area," nor did the context give any clue. As a consequence such a wide variety of answers were received as to make the information of no use for the purpose intended.

The ability to word questions so as to avoid misunderstandings comes partly through a careful analysis of the subject and a knowledge of exactly what is wanted. However, not every one possessing a thorough knowledge of a subject can express himself with equal clearness, as a careful reading of a number of text-books will quickly demonstrate. For that reason the wording of the questions should be in the hands of one who has unusual ability at expressing himself clearly.

6. *Make it easy for the recipient to answer the questions.* The amount of work involved in replying to the questions is an important factor to consider. In most cases the one who must answer is busy and, even though interested, he is more apt to give the desired information if the questions are worded so that he has very little writing to do. In fact, if there is any indication that a considerable amount of writing will be necessary, the natural tendency is to postpone or get out of answering it at all. For that reason it is highly desirable to have as many questions as possible so worded that he can check his answer, fill in "yes" or "no," or state a figure.

Besides making it easy for him to answer, the wording of questions in this way makes for ease in tabulating his replies. Nothing is so difficult to classify and tabulate as details or qualifying statements, and when these are numerous, the expense of assembling the data often becomes so great as to be out of proportion to the value of the information.

7. *Arrange questions in logical sequence.* Two great advantages accrue from the arrangement of questions in logical sequence. In the first place, the framer of the questionnaire can make certain that he has thoroughly covered the subject. In the second place, the logical order makes the transition from one question to another so easy that the person answering the questionnaire does not realize its length. In this way important questions are gradually introduced which if standing alone might seem objectionable, but when considered in sequence with others seem entirely proper.

For these reasons it is the part of wisdom to arrange the questions in the most logical and effective order. Anything which makes for ease in reply brings about more numerous returns and more accurate information.

8. *Avoid long or involved questions.* Questions should be short and to the point, only one subject being covered in each. Compound or involved sentences should be avoided not only because they may be easily misunderstood, but also because it is difficult to tabulate the replies.

For example, in a questionnaire sent out by an information bureau the following question was asked: "In what city do the men buy their suits, overcoats, and shoes, or do they buy altogether by mail?" Not only is the wording of this question ambiguous as it seems to ask for two combinations of three things, but an additional variable is included in the phrase "In what city?" Naturally, the replies were so varied that it was impossible to tabulate them so as to show anything definite.

9. *Wording of questions should not indicate the answer desired.* It is the purpose of the questionnaire to find out the real facts. Any indication in the question that a certain answer is desired lessens just so much its accuracy. Positive questions are most desirable. Negative questions as a rule should be avoided.

Not long ago a very ambitious questionnaire on "stores

handling methods" was circulated among the members of a certain trade association. This questionnaire was admirable in almost every respect, but when the replies came in and were tabulated the committee found that they did not represent actual practice. The questions in many instances had indicated what was the best practice and rather than admit that their firm was deficient in this respect, the executives answering the questionnaire indicated as being in actual existence practices which they were installing or planned to install shortly. In many other cases they indicated that certain routines were used which personal investigation brought out as having been superseded by other methods.

10. *Make the questionnaire brief.* The questionnaire must, of course, cover the subject, but at the same time it should be as brief as possible. Every question not absolutely essential which is added increases the danger of its being unanswered. No rule can be given as to the most desirable length, as this varies with every subject.

In general, however, it may be said that the more technical the subject the longer the questionnaire can be made. The questionnaire prepared by the Committee on Elimination of Waste, already mentioned, illustrates an extreme example of length made necessary in order to cover the subject fully. The same is true when the subject-matter is of special interest to the recipient. Questionnaires, however, which must be answered by the trade should be short, and even then the number of replies will probably be small. Many of the government questionnaires are flagrant violations of this rule. They are answered in spite of their length because of their official character. If the same questionnaires were sent out by a private individual or concern, few replies would probably be received.

A good many other cautions could probably be given which would be of value in preparing the questionnaire. Most of these, however, apply to particular types and, to a

considerable extent, they will be apparent from the nature of the problem involved.

It is sometimes advisable to include in the questionnaire certain questions which will check the accuracy of other questions. However desirable this may be in specific instances, it does not seem advisable to make it a general rule, inasmuch as this would unduly increase the length of the questionnaire.

If due care has been taken to observe the foregoing rules in the preparation of the questionnaire, the disadvantages of insufficient returns and inadequate replies can be avoided, provided it is sent to the proper persons. A good screwdriver may make a poor chisel, and a questionnaire, however well prepared, which is sent to the wrong person for answer, can only fail to produce satisfactory results.

ENLISTING THE RECIPIENT'S INTEREST

The preparing of a questionnaire which thoroughly covers the subject is one important step towards getting satisfactory information. That alone will not insure adequate replies unless the interest of the recipient has been aroused so that he will make the effort to answer the questions.

The "selling" of the questionnaire to the person from whom the information is desired is therefore a very important point to consider. In most cases this is accomplished through a personal letter accompanying the questionnaire which states frankly the reason for its preparation and why the person addressed is solicited for a reply.

A short, courteous, forceful letter will do a great deal toward putting the recipient in the proper frame of mind so that he will not only answer the questions promptly, but will give accurate and dependable information.

This letter should state the time limit within which a reply must be received and urge the recipient to make his reply at once. This letter, if possible, should be typewritten and personally signed. If the number of questionnaires

makes this impracticable, the letter should be multigraphed and the name and address of the recipient filled in on the typewriter, care being taken to make the letter look, as near as possible, as though it were typewritten.

If at all possible, the typewritten letter should be used by all means, as numerous tests have shown that the probability of replies is greatly increased thereby. If the questionnaire is short, a separate letter is sometimes unnecessary, its place being taken by an introductory paragraph or two in the questionnaire itself. In such cases, however, this introduction should incorporate the same desirable features as a separate letter.

In all cases, however, the interest of the recipient must be aroused. Sometimes this can be done by showing what value the information will have. At other times special inducements must be offered. Questionnaires on technical subjects sent to authorities or persons vitally interested in the subject are very apt to draw good returns. Especially is this true when the answering of the questionnaire is made a point of vital interest to them.

Questionnaires which have a purely commercial content are not so apt to produce a large number of replies. Consequently, more questionnaires have to be sent out in order to secure an adequate number of returns. In the case of questionnaires sent to customers or users of the product in order to get personal information, it is usually not difficult to secure replies provided the questionnaire is brief and sold to them in the proper way.

In all cases, however, the interest of the recipient will be affected by the inducement which is offered him. Two usual forms are to offer him a digest of the findings and to promise him to keep the information confidential. The character of the subject will decide which of these it is best to use. Another inducement which is frequently offered, especially in market questionnaires, is to promise not to send a salesman to call.

Another factor which vitally affects the interest of the

recipient has already been mentioned, that of setting it up in such a way as to make it easy for him to answer the questions. However, the probability of getting him to reply is still further increased if a self-addressed, stamped envelope is enclosed so that all he has to do is to answer the questions, fold the questionnaire, put it in the envelope, seal it, and drop it in the outgoing mail. In some cases the use of a special-delivery stamp, because of its novelty, has induced a large number of prompt returns. In the case of a short questionnaire desiring particular information, it is frequently possible to print it on the back of a post-card, which may be filled out and dropped in the mail, thus reducing the work of answering the questionnaire to a minimum.

DISTRIBUTING THE QUESTIONNAIRE

When a carefully prepared questionnaire has been properly presented, a good start has been made; but in order to secure adequate returns in quality, it must be placed in the hands of those best fitted to give the desired information. The effective distribution of the questionnaire calls for consideration of the following:

1. The selection of the persons to whom it shall be sent;
2. The trying out of the questionnaire in a limited way;
3. The determination of the number of questionnaires to be used;
4. The decision as to following up;
5. The method of duplication.

1. *The selection of the persons to whom it shall be sent.* What has been said in a previous section regarding the importance of selecting the persons to be interviewed applies with equal force to the selection of persons to whom it is advisable to send the questionnaire.

Obviously it should be sent only to interested parties. To a considerable extent the subject-matter of the questionnaire will determine who these are. In general, however, it may be said that if the questionnaire is of a technical

nature, it should be sent to authorities on the subject familiar with both the technique and use of the proposition.

If, however, the subject-matter is commercial in character, it should be sent to business establishments, that is, to wholesalers, jobbers, retailers, and so forth. On the other hand, if the subject-matter is of a personal nature, it will be necessary to go to the individual user or customer in order to get the real facts.

The sources of these names in the case of questionnaires of a technical nature will probably be from the personal files of the investigator or his concern. In other cases it may be necessary to use a list compiled from commercial registers, city directories, purchased mailing lists, and so forth. No general information can be given on this subject further than the foregoing. But every effort should be made to get the questionnaire to as many as possible of those capable of supplying the desired information. Thus the probability of adequate returns is greatly increased.

2. *Trying out the questionnaire in a limited way.* No questionnaire should be released for general distribution before it has been tried out in a limited way and the replies carefully tabulated, in order to make sure that it is pulling the desired information. Of course, the thoroughness of this test will depend entirely on the importance of the questionnaire. Where in some cases a casual reading will suffice, in others a real try-out on 10, 25, 100 and perhaps more is desirable. Especially is this desirable when several hundred or thousands of questionnaires are to be distributed or where there is any doubt as to the interpretation which will be given to certain questions.

3. *Determining the number to be sent.* The third point to be considered in the distribution of the questionnaire is that of "how many." Of course, this will be controlled to a considerable extent by the number of persons who can furnish the desired information. There are other limiting factors, however, one of the most important of which is the

probability of reply. The general consideration which influences the number and quality of reply has been discussed in the preceding pages. With these points in mind the decision as to the desirable number to be sent becomes a simple matter of mathematics.

4. *The follow-up.* When the questionnaire is of great importance, it will usually be found desirable to send out a follow-up letter after a certain period has elapsed. The exact period depends upon the questionnaire. Care must be taken not to follow-up too closely; yet, on the other hand, it is equally imperative not to wait so long that the questionnaire has become cold. If the replies are checked, the time when they are falling off will be promptly shown, and this will indicate the proper time to release the follow-up.

When a follow-up letter is sent, it should be worded very diplomatically, reiterating the importance of answering the questionnaire and emphasizing the value of such action to the recipient. In more than one case such a letter has resulted in bringing in a considerable number of answers, some times practically as many as were received in the first place.

When no reply is received to the first follow-up after waiting a reasonable length of time, it is hardly advisable to follow up again unless some unusual point can be raised which will arouse interest. Occasionally a recent event, a speech, and so forth, will furnish the theme for another follow-up which sometimes secures results where the others failed.

In other cases, when no reply is received to a long questionnaire, it can be frequently assumed that its length has discouraged many from replying. A short letter asking the recipient, if he is too busy to answer the questionnaire, to jot down replies to the leading questions incorporated in the letter will oftentimes bring in a number of replies which otherwise would not have been received. If the questions incorporated in this follow-up letter are carefully selected and worded, very good results can be secured in this way.

5. *The method of duplication.* There is no advantage gained in trying to conceal the formal character of a questionnaire. Special typing need only be used in cases where it is short or where only a few are being sent. In other cases it is best to print, multigraph, or mimeograph it.

In all cases a good grade of paper should be used and attention given to the effective set-up of the questions so that the questionnaire as a whole creates a favorable impression. Often the foregoing is overlooked and because of the number of questionnaires to be sent a cheap grade of paper is used which does not take ink well. This is a source of great annoyance to the person who answers it, and due to the blots and blurs it is often a very difficult task for the compiler to decipher some of the answers.

HANDLING THE RETURNS

Many times in preparing a questionnaire, the preceding three points have been considered, but the method of handling the returns has not been taken into account. As a consequence, when the replies come in, it is frequently impossible to tabulate them effectively, or when this can be done, it requires an excessive amount of work.

New York City,
Dec. 31, 19-

Dear Sir.
In connection with a survey of motor trucks in manufacturing industries, we would appreciate your kindness in supplying the number and capacity of motor trucks used in your business, if you can do so without too much research on your part.

A summary of the figures obtained will be made up for concerns supplying data, and a copy sent you if you desire. A stamped envelope is enclosed for your convenience in replying.

Yours very truly,

JONES McKAY COMPANY
Research Bureau

Figure 3: Letter accompanying questionnaire shown in Figure 4.

Jones McKay Company,
New York City

Number of motor trucks in use December, 19— ____________

Number of 1-ton capacity and less ____________

Make of truck ____________

$1\frac{1}{2}$ Tons ____________	Make of Truck ____________
2 Tons ____________	Make of Truck ____________
$2\frac{1}{2}$ Tons ____________	Make of Truck ____________
3 Tons ____________	Make of Truck ____________
$3\frac{1}{2}$ Tons ____________	Make of Truck ____________
5 Tons and over ____________	Make of Truck ____________

Number and size of additional trucks likely to be purchased during the next six months ____________

Company ____________ Signed ____________

Position ____________

Figure 4: Example of an effective questionnaire.

A good example in point is the questionnaire which was sent out by the Congressional Committee appointed to inquire into the salary reclassification of post-office employees. This committee designed the questionnaire to be filled out by postal employees all over the country. After the replies were in, there was difficulty in tabulating them because:

1. Some questions could not be tabulated because the answers were expressed in a variety of ways.
2. Some questions which were to be tabulated did not show the unit in which the reply should be expressed. As a consequence, these replies had to be interpreted in terms of a common unit, which required a considerable amount of extra work.
3. The replies being so numerous, it was necessary to use a Holerith card; but the questionnaire contained three times as many questions as could be taken care of on the Holerith card.

In view of the number of replies to this questionnaire, the failure to consider these and other points regarding the

handling of the returns made it necessary to employ an excessive number of people to do the tabulating, as well as making this job take much longer than was necessary, with consequent excessive cost.

In a later chapter the question of tabulation will be taken up at considerable length, at which time will be brought out the points which have to be considered in this connection. Further discussion, therefore, will not be attempted at this point except to reiterate the necessity of considering this matter very carefully during the preparation of any questionnaire.

As the replies to the questionnaire come in, the question of acknowledgment will come up. Usually, if the letter of transmission has been worded properly, no acknowledgment will be expected. In many cases, however, an acknowledgment is desirable, especially in cases where it is advisable to maintain the interest of the recipient or make use of him at a subsequent time.

Size of Trucks, Tons	Number of Concerns	Number of Trucks
1 or less	89	166
1½	24	33
2	39	57
2½	12	17
3	19	29
3½	16	27
4	5	5
5	26	36
Not stated	2	

Figure 5: Tabulation of replies to questionnaire shown in Figure 4.

In cases where an acknowledgment is deemed advisable, the requirements of the particular case will dictate the character of acknowledgment. In most cases, however, when a draft of the findings has been promised and tabu-

lation can be quickly made, this draft in itself will constitute all the acknowledgment that is required.

SUMMARY

A good questionnaire is one that gets results; that is, one that secures a sufficient number of adequate replies so that it is possible to make logical deductions from the data given.

A good example of such a questionnaire is the one referred to by E. S. Bradford in *Administration,* February, 1923. In Figures 3, 4, and 5 are illustrated the letter introducing the questionnaire, the questionnaire itself, and the tabulation of replies. Five hundred copies were sent out and 277 replies were received, which is an unusually high return for this class of questionnaire.

For every effective questionnaire there are many failures. In fact, the reader has no doubt received many during the past year which he has promptly consigned to the waste basket. Here is a considerable economic loss which in most cases must be added to the cost of distribution, since the majority of questionnaires bear upon marketing problems.

Closer analysis and study before sending out questionnaires will reduce this wastage materially while at the same time producing more numerous and accurate returns. This is accomplished when:

1. Careful attention is given to the number, character, and wording of the questions;
2. Real salesmanship is used to sell the recipient on the importance of giving the information desired;
3. Care is used to send it to those from whom adequate replies can reasonably be expected;
4. Adequate provisions are made for quickly and economically compiling the information from the returned questionnaires.

XI

THE NATURE OF THINKING

The purpose of thinking and its place in the investigational procedure. Kinds of thinking. Reflective thinking the only true type. Thinking defined. Mental powers underlying thinking. The fundamental laws of thought. The functions of thinking: (1) concepts; (2) judgments; (3) inference; (4) reasoning. Close interrelation between concepts, judgments, inference, and reasoning.

Thus far in the investigational procedure we have spoken but little of thinking, or the application of thought to the investigation of problems. This by no means implies that thinking is unnecessary in the earlier stages of the investigation. Quite the contrary, the preliminary analysis calls for careful thinking in order to organize the work and develop suitable working hypotheses; but this thinking can only be of the most casual sort, since the mind possesses but few facts to work on. Such thinking is more likely good guessing than the careful systematic and deliberate reasoning which takes place after sufficient facts have been gathered.

Then, too, in the collection of facts one is constantly called upon to think in order to decide whether to accept or reject the data which are presented to the attention. But here the thinking involved is of the simplest type and designed solely to indicate that the facts accepted are probably pertinent or seem to have a bearing on the subject, and that those rejected are unessential.

In fact, any attempt to form judgments, draw inferences, or formulate final conclusions before making an adequate collection of facts, can only result in disaster. It is rarely possible for conclusions, hastily drawn from the consideration of a few isolated facts, to agree with those formed maturely after consideration of all of the facts.

Jumping at hasty conclusions through failure to suspend judgment until the essential facts have been gathered is one of the principal causes of failure in investigational work. But the business executive is the chief offender in this respect. Investigational work trains the individual engaged in it to habitually suspend his judgment until he has studied the problem from all sides. But not so with the executive. His instinct is to act first, and afterwards think up reasons for his action. This tendency is perhaps one the principal reasons why so many business men fail.

The cultivation of the habit of suspending judgment until all of the facts have been gathered is, therefore, not only essential to the investigator, but even more so to every executive empowered to make decisions at any time. This habit is not easy to form, however. In fact, it takes the most rigorous mental discipline in order to acquire it, but once acquired it is the best insurance possible against unwise or unprofitable decisions.

This was very clearly brought out by John Dewey[1] as follows: "The undisciplined mind is averse to suspense and intellectual hesitation; it is prone to assertion. It likes things undisturbed, settled, and treats them as such without due warrant. Familiarity, common repute, and congeniality to desire are readily made measuring rods of truth. Ignorance gives way to opinionated and current error—a greater foe to learning than ignorance itself. . . . Our predilection for premature acceptance and assertion, our aversion to suspended judgment, are signs that we tend naturally to short-cut the process of testing. We are satisfied with superficial and immediate short-visioned applications. If these work with moderate satisfactoriness, we are content to suppose that our assumptions have been confirmed."

While, as stated before, one must utilize a certain amount and kind of thinking in the first two steps in the investigational process, the purpose which dominates the work in these stages is that of organizing the work and gathering

[1]Dewey, John, *Democracy and Education,* p. 222.

the necessary facts. Now that the facts have been secured, the primary purpose becomes that of finding the correct explanation, formulating a logical conclusion, or devising a practical solution.

It is the function of thinking to accomplish these purposes. Thinking, therefore, is a fundamental element involved in all the remaining steps in the investigational procedure, and, therefore, it will be advisable to make a thorough analysis of the thinking process as a whole, before taking up the subsequent steps in the procedure.

KINDS OF THINKING

Thinking is such a common term that it seems that every one should be familiar with its meaning. However, the fact that the term "thinking" is in such common use does not by any means indicate that its nature is thoroughly understood, or even that the persons making use of the process know how to think correctly.

As a matter of fact, it is an every-day occurrence to hear the remark: "I think so and so is the case." However, this statement is not always the result of thinking on the part of the one making the assertion. Quite the contrary, it is most frequently an idea or a conclusion that he has appropriated bodily from some other person or has read in some newspaper, magazine, or book. This statement or opinion he has accepted without expending any mental effort further than the very slight amount involved in the action of incorporating it in his general body of knowledge.

What passes for thinking in ordinary life is not at all the type which it is necessary to apply to the explanation of the facts which have been gathered, or to the devising of a satisfactory solution to the problem. The difference between the ordinary type of thinking and the sort of thinking which results in solving problems will be clearer, perhaps, when the distinction between what psychologists term the different kinds of thinking is understood.

In a broad way, thinking is sometimes defined as "that phase of the mind's activity which regards any specific object which may be presented to it in the light of the general body of knowledge." In accordance with this definition, thinking may be of several kinds and degrees.

First of all, there is that type of thinking which may be called *reverie*. Specifically, it includes those thoughts which pass through one's mind while relaxing. No sustained or applied effort is required. The thoughts simply come and go as they please. Sometimes they are valuable; most frequently they are utterly futile—so much so that the common name for describing this type of thinking is "day dreaming."

The second type of thinking leads directly from the reverie and is concerned with making decisions regarding matters which interrupt us while doing something else and force us to decide something one way or another. For want of a better term, this is often called *spontaneous thinking*. In other words, in the reverie, free play is given to the thoughts. In the second type of thinking it is necessary to make up the mind regarding some matter, and it is this introduction of an outside stimulus which differentiates these two kinds of thinking. However, the process of thought involved is still of the most simple type. No sustained effort is required, the decisions usually being made in a very loose manner after consideration of only such factors as come up at the immediate time.

In fact, herein lies the broad distinction between this type of thinking and a third type, which is termed by psychologist's *rationalizing*. The foregoing type, it will be noted, was concerned with making up the mind regarding something that came up at the instant. Rationalizing is concerned with justifying one's beliefs and opinions which have been questioned by some one. A very considerable proportion of the thinking done by many men is connected with forming "alibis," which is nothing more or less than rationalizing.

As brought out in a previous chapter, it is astonishing how many of one's beliefs and opinions have been acquired in ways which could not bear close analysis. These beliefs have been acquired through association, reading, inheritance, and so forth. They constitute a very large portion of one's general knowledge on any subject and are bound to influence him in most of his affairs. In general, one tends to believe what he wants to believe, and does so quite in spite of many good and sufficient reasons which may be brought forward to show that his belief is unsound.

When, therefore, in gathering together the facts, he encounters any which tend to contradict any of these opinions or beliefs, he instinctively attempts to justify his belief through a process of thinking which has for its purpose the bringing together of proof which will substantiate his opinion in the matter. Especially as people grow older they grow more set in their opinions and beliefs, and the harder it is for them to take new experiences at their face value and change any of their beliefs to conform with new facts. Only the broadest minded people have the courage to attack their own beliefs and opinions, subjecting them to careful analysis and rejecting such as do not conform with observed facts.

The fourth type may be called *reflective* or *creative thinking*. It is the kind of thinking which is done when a subject is calmly and thoroughly analyzed from every angle in order that it may be more thoroughly understood. This is the only type of thinking which really deserves the name and, in fact, many psychologists do not consider that the three types which have just been mentioned should be classed as thinking at all.

However that may be, in order to bring out the nature of thinking, and in order to show plainly how necessary it is to develop the creative and reflective type, these different kinds have been briefly discussed. They cannot be dismissed entirely from consideration as they operate at all times, quite unconsciously perhaps, and they are often of

value in suggesting possible ideas, plans, and so forth, as will be seen later. However, in general they are of little use in the conduct of an investigation. In fact, when they are allowed to influence the direction of effort, they serve only as a hindrance and not a help.

Sometimes all forms of thinking but the creative type are grouped together under the term "loose thinking," the very name indicating that it is unguided or without design, whereas creative thinking is regulated by some desire or design. There are still other forms of thinking and uses of this term, but as they do not properly apply to investigational work they can be passed up in this discussion and the further discussion of thinking be confined to the last type mentioned, namely, creative or reflective thinking.

Reflection, in many ways, is an excellent name for this type of thinking. Reflection suggests illumination, and one of the primary purposes of thinking is to focus the light of general knowledge on particular observations and facts bearing upon the problem, resulting in so illuminating them that the essential character and underlying elements will be clearly apparent, and their relationship to the problem and use will be revealed.

THINKING DEFINED

Thinking is the active, careful, and persistent effort to properly interpret the facts furnished by experience, and adjust means to ends in order to overcome a difficulty or solve a problem. This is admittedly a narrow view of the thinking process. There is no doubt but that some of the finest examples of thinking have been with no end in view. Some of the world's greatest discoveries are examples of reflective reasoning which have been pure examples of reasoning for reason's sake, but investigation being solely concerned with tangible affairs, it seems advisable to restrict the use of thinking to that phase which is brought out in the definition given above.

With this qualification, let us examine for a moment the definition which has been given. Thinking, in its true sense, is active and not passive. Thoughts which are productive of real benefit do not, as a rule, simply come to the mind. They are the result of applied effort. They, further, call for accurate mental processes and persistency on the part of the thinker.

Thinking is concerned with the interpretation of the facts observed, with the discovery of new meanings for the facts, and with the finding out of new ways to utilize them effectively. Such thinking is not spontaneous, but requires genuine, concentrated effort, combined with the ability to direct and control the workings of the mind.

Although varied in form and content, thinking is always directed toward a single end—*to interpret* the past and present, and through means of such interpretation *to forecast* the future. Only through thinking can we understand what has happened in the past and plan our future actions. To become a part of our working knowledge, every observation, regardless of its nature, must be correctly interpreted. This interpretation has for its purpose the revealing of its essential characteristics in the light of some fundamental principle or law which governs the observation in question.

The purpose of thinking, therefore, is to discover those fundamental and universal laws which produce or influence the effects observed. Consequently, thinking is not so much a distinct, conscious process as it is an organization of all of the conscious processes involved in the interpreting of the facts furnished through observation and experience, and the organizing of them so as to achieve a desired end.

In discussing the subject of thinking, it is unfortunately not possible to treat it in anything like the exhaustive manner which the subject deserves. In fact, the brief outline given here only summarizes the teachings of authorities like Dewey, Hibben, and Jerons, to name those especially whose influence has been perhaps greatest. The purpose at this time is merely to lay bare some of the basic considerations

involved, so that the reader may be able to train himself in clearer and more accurate methods of thinking.

In fact, it is presumed that the investigator has studied some standard text-book on logic. If he has not, it will be well for him to read some of the selected references given at the end of this book, especially those which deal with the formation of judgments, the drawing of inferences, and the developing of final conclusions. While the attempt here will be made to set forth the basic principles of logical thinking in simple and easily understood terms, it will be purely from the standpoint of the application of thinking to the solution of commercial and industrial problems. At all times, the view-point of these chapters will be the practical use which the executive, the engineer, or the scientist makes of thinking, in solving the problems which he encounters in his daily work.

MENTAL POWERS UNDERLYING THINKING

With this explanation of the purpose, let us now consider the subject of thinking in the broad sense, preliminary to taking up the third step in the investigational process. In so doing, it will be advisable, first of all, to call to mind the mental powers which are employed—that is, the fundamental faculties without which thinking could not exist. These basic mental powers are three in number:

1. The power of discrimination;
2. The power of detecting identity;
3. The power of retention.

In any observation or experiment, the power of discrimination is utilized. In fact, one could not have a sensation or feeling except by discriminating it from something else which preceded it. Constantly throughout one's working hours he is engaged in discrimination, and many of the ordinary observations do not involve any higher mental process.

But discrimination alone would get one nowhere in so far

as the discovery of new ways and means of solving difficulties are concerned. Discrimination alone furnishes negative information. It deals with the past only, and does not show anything regarding the future. Every sensation stands out alone, with no tie binding it to any other. The coordination of sensations is accomplished through the power of detecting identity, and this power, more than any other, lies at the basis of thinking.

The detection of identity is manifold in its application, and corresponds to what logicians term "the fundamental laws of thought," which are:

1. The Law of Identity; in other words, whatever is, is.
2. The Law of Contradiction; in other words, a thing cannot both be and not be.
3. The Law of Duality, or, as it is sometimes called, the Law of Excluded Middle; in other words, a thing must either be or not be.
4. The Law of Sufficient Reason; in other words, a thing is accepted as true when its correctness is practically demonstrated, although absolute proof cannot be furnished.

The first of these laws is axiomatic, expressing as it does that a thing at any moment is perfectly identical with itself.

The second law points out that contradictory qualities can never be joined together. The same object may vary in its different parts, or even at different times, but it cannot have opposite characteristics in the same place at the same time.

The third of these laws completes the other two, and brings out the fact that in connection with every observation there are two possible alternatives—affirmative or negative. As Aristotle has said that between opposite assertions there can be no middle ground, it is customary to describe this law in the text-books on logic by the term "the Law of Excluded Middle."

The fourth law is that of sufficient reason, which, simply stated, means that every judgment or conclusion must be based upon some satisfactory ground which justifies it. This

law is essentially the foundation upon which all thinking is based. It implies that our knowledge, as a whole, consists of a system of interrelated and coordinated parts, and that any single element can be determined only when its relation to some other element or elements is known. The importance of this law will be more clearly established when the later steps in the investigational process are taken up, but it is sufficient at this time to bring out the fact that through this law the interdependence of the various elements of knowledge is clearly shown, thus making it possible properly to interpret the past and forecast the future, which is the function of thinking.

Summarizing: The Law of Identity demands that there be a basis of constant reference in all observations. The Law of Contradiction requires that they be treated in a consistent manner. The Law of Excluded Middle requires that the collection of facts be exhaustive so that the survey of possibilities may be complete. And, the Law of Sufficient Reason requires that the explanation of the facts observed be adequate.

To revert to the discussion of the powers of the mind, the first two have been considered: discrimination and detecting identity. Now comes the third power, which is that of retention or memory. Obviously, the memory of previous experiences is necessary in the formation of even the most simple judgments. In fact, we could not think at all were it not for the retention of the knowledge and experience gained in the past. In a previous chapter the memory and its service have been discussed, and further consideration of this subject is therefore unnecessary at this time and we can pass to the analyis of the functions of thinking.

THE FUNCTIONS OF THINKING

So long as everything runs along in the same old groove no real need for thinking arises. It is only when something out of the ordinary happens that cannot be handled accord-

ing to habitual methods that we are forced to think. In other words, thinking requires a stimulus, and that stimulus is supplied by the recognition of a difficulty to be overcome, the existence of certain facts which require explanation, or the propounding of a problem that calls for solution.

The first active step in thinking, just the same as it was in the investigation, therefore, is the recognition of a problem or difficulty. But, properly speaking, this is not so much a step in thinking as it is the urge or push which starts the train of thought in operation.

Presupposing, then, that the stimulus for thinking is supplied by the problem inherent in the investigation itself, not to speak of the need for explaining and of finding out the real purpose and use of many of the facts which have been observed, we will pass on to discuss briefly the four functions of thought itself. These are:

1. Concepts
2. Judgment
3. Inference
4. Reasoning

CONCEPTS

Thinking begins with the formation of concepts. Concepts are the products of observation. They are the mental images or ideas which stand for that which has been seen or heard. Into this concept the characteristics of the thing observed are united in a single expression, which stands as a symbol for all that is covered by the observation.

For instance, a typewriter is a concept which stands for a piece of equipment with a certain established function. Behind this concept, and understood but not expressed, are all the various elements which go to make up the typewriter itself, together with the various uses to which it can be put.

JUDGMENT

Almost at the same time as the concept is formed in terms of which observations are expressed, the second function of

thinking is performed—that of forming judgments as to what the facts in question really mean. This is done by referring the observations to other concepts which constitute the body of general knowledge possessed by the individual.

Forming judgments calls for careful definition of the facts through classification or arrangement in a systematic order, and the necessary interpretation, testing, or editing of such as require modification before they can be used.

Speaking in terms of investigation, all the data which have been collected exist in the form of judgments, and it is only in terms of these judgments that it is possible to think about the information thus gathered. Stated in another way, judgments represent the raw material of thought. As the product can be no better than the raw material from which it is manufactured, so a conclusion or a solution can be no more accurate than the judgments upon which the inference is based.

Too much emphasis can scarcely be placed, therefore, on the necessity of forming clear and unmistakable judgments regarding the facts that come under our observation. No matter how carefully one may perform the subsequent steps in thinking, if the facts are vague, or if the judgments are unsound, conclusions are apt to be wrong and solutions impracticable.

This reference of the facts observed—concepts, in other words—to the related body of knowledge, completes the formation of the judgment. This is a form of interpretation, and really constitutes the central factor of thinking. The essential function of the judgment is to give definiteness to the concept by classifying it according to its essential characteristics. This act of classification leads to the foundation of generalizations which lie at the basis of judgments. The exact line of distinction between concepts and judgments is therefore difficult to draw, inasmuch as it is impossible, for all practical purposes, to conceive of a concept existing separately from the judgment which is formed regarding it.

INFERENCE

Just as concepts pass immediately into judgments, so judgments give rise to more complex ideas through inference. This function of thinking consists in discovering or finding out whatever may be implied in the judgment and inherent in the concept but which is not explicitly stated. It is a process of casting about in order to find out the explanation of the facts, the way to overcome a difficulty, the cause of an observed effect, or the effects to be expected from an assumed cause.

An investigator, going through a factory, sees the windows covered with many weeks' accumulation of grime and dirt. This is a concept, and the judgment immediately formed is that the windows are dirty. But almost immediately the mind goes beyond that to draw inferences that because of the dirtiness the light is cut off from the workers, and that because of this fact there is difficulty in doing work which is at all intricate in character; that work of all kinds will probably be slowed up because of insufficient illumination; that lighting bills for electricity will be higher than would be the case were maximum use made of daylight, and so on.

Inference is based upon the well-known psychological fact that in our simplest perceptions or observations the interpretation of the observation always goes beyond the actual content of the data. From the body of general knowledge bearing on the subject, one is able to infer more regarding a particular observation than was actually perceived. Experience has demonstrated, however, that these inferences are probably true because they conform with other knowledge gained from other sources and directly follow what is known to be true.

But inference is not confined alone to the interpretation of judgments. It takes two or more related judgments and joins them together in such a manner as to produce added knowledge which neither judgment alone would furnish.

For instance, carrying the observation of the dirty windows one step farther, if subsequently the investigator should observe a high percentage of defective work coming from the men working adjacent to these windows, it would be sound to infer that the condition of the windows was, partly at least, responsible for the defective work.

Inference, then, is that function of thinking which endeavors to read new meanings into the judgments and to form new combinations of them which will result in the formulation of a hypothesis or an explanation which will satisfactorily account for the facts and lead to a solution of the problem. This hypothesis is not a conclusion, nor is it a solution. Its truth or falsity has yet to be tested, and that is the fourth function of thinking, which is known as reasoning.

REASONING

Reasoning is the act of testing or weighing the practicability, feasibility, or validity of the various suggestions which have been developed through the process of inference. At the same time as these ideas are tested, the very procedure itself leads to the formation of still more definite ideas, leading to a more accurate hypothesis, and finally resulting in the logical conclusion or the practical solution.

This testing is performed both inductively and deductively. The former is a sort of internal check. The facts observed are carefully inspected in order to make sure that the hypothesis satisfactorily accounts for them. This is done through those methods which for years have been associated with the name of John Stuart Mill:

1. The Method of Agreement
2. The Method of Difference
3. The Joint Method of Agreement and Difference
4. The Method of Concomitant Variations
5. The Method of Residues

Although the validity of a conclusion may be thoroughly established inductively, it is advisable, before accepting it

as final, to test it deductively. This is accomplished by making the hypothesis the major term in a syllogism. Other facts which bear on the problem are gathered and through the process of syllogistic reasoning they are referred to the hypothesis. If every fact which can be gathered fits in its proper place in accordance with the hypothesis being tested, then it can be assumed that the conclusion is sound.

For instance, the discovery of gravitation was, it is said, suggested by Newton's observation of the falling of an apple. This suggestion led to the noting of the fact that most other objects possessing weight fell toward the earth. The generalization was formed that the earth possessed an attraction which drew all objects toward it. This generalization was then tested inductively, and finally deductively. As no objects, either on the earth or in the heavens, were found that did not conform to the hypothesis, it was fully demonstrated as being sound, and has taken its place as one of our natural laws.

Although concepts, judgments, inferences, and reasoning represent separate functions of thinking, each is closely connected and coordinated with the other functions. The concept is an essential element in the judgment, for the latter is merely the concept made definite through definition and classification. Inference in itself is only an elaborated judgment which is reached indirectly, and in the formation of judgments it is impossible to eliminate inference inasmuch as the judgment always contains more than is actually observed—just how much depends upon the general body of knowledge on the subject. Finally, reasoning tests the validity of the suggestion or inference and verifies the conclusion which it suggests.

In order that thinking may be correct, it is necessary for the concepts, judgments, and inferences to be true. To be true, a concept must clearly and adequately include the essential elements in that which is observed or experienced. Moreover, it must be constant in character and not subject to variation.

A judgment, to be true, must express the general relation of certain concepts to each other, or to the general body of knowledge, and this general relation must in no way disturb the general order which characterizes the system of knowledge into which it is to fit. If the judgment, on the other hand, refers the observation directly to its appropriate concept, then all such references must be exact.

To say that an inference is true implies that the conclusion reached through the process of inference must be of such a nature as to be fully justified and warranted by the facts from which it has been developed. In order that a conclusion may be true, every step of the thinking process up to this point must be correctly performed. Clearness, adequacy, consistency, exactness, and validity are practical tests which indicate the truth of a conclusion, the correctness of an explanation, and the value of a solution.

In this discussion of the process of thinking, the standpoint has primarily been that of the functions which are involved, rather than the use to which thinking is put, and the idea has been to picture them briefly, but clearly. In the subsequent steps in the investigational procedure which will now be taken up, the use of the thinking process will be developed, and as the different functions come into play in the investigation, each will be fully explained.

In fact, as it has already been brought out, there is no time, from the very beginning of the investigation to the end, that thinking is not required. The extent of its use, however, depends much upon the stage of the work, but at all times the same essential functions are involved. With this understanding of the close relation that exists between the thinking and investigation process as a whole, the discussion of the procedure itself will be resumed in the following chapter by taking up the next step, that of "Definition and Classification."

XII

DEFINITION AND CLASSIFICATION

Organization of data. Definition—its meaning. Rules of definition. Classification and what it includes. Purpose of classification. Kinds of classification. Procedure of classification. Laws of classification. The recapitulation sheet and examples of its uses.

As soon as an adequate collection of facts has been made, the third step in the investigational procedure begins, which is concerned with the organization of the data collected. Defining and classifying; testing and interpreting; and finally, tabulating and presenting the facts, constitute closely related but distinct steps in "forming judgments."

Obviously many judgments must be formed during the act of observation, but it should be realized that these are but tentative judgments, subject to recheck and possible modification or perhaps even absolute rejection at a later time. True judgments can only be formed after the observations or facts have been related to other observations or facts, so as to bring out their full meaning and significance.

Now in order effectively to relate the facts to each other and to the general body of knowledge on the subject, it is essential for the investigator to:

1. Know the exact meaning of the facts in question;
2. Possess an organized body of general information bearing on the subject.

In forming judgments, the first step is to ascertain the real meaning of the facts through definition. This is essential, for obviously it is impossible to know what use can be made of these facts until their qualities or attributes are known. On the other hand, everything is relative, and the facts observed can only be described or understood by throwing them into comparison with other facts of a similar

nature through classification. Therefore, the first step in forming judgments about the observed facts is that of *definition and classification.*

But there must be some means of making sure of the accuracy of the work of definition and classification. This is accomplished through applying certain practical tests to the judgments thus formed. These tests may disclose that many of the tentative judgments must be rejected and others perhaps changed and modified before they can be used. The procedure involved in *testing and interpretation* constitutes the second step in the forming of judgments.

Then, too, many of the facts are of such a character that they require tabulation or presentation in tabular or graphic form, as, for example, statistics, which, in order to be readily grasped by the mind, need to be presented in tables or summaries. *Tabulation and presentation* constitute, then, the third step in forming judgments.

All these are stages in the formation of judgments. Each is closely related and mutually dependent on the other. In function, however, each is distinct, and the special character of the service performed will be clearly brought out as they are considered more fully.

Before taking up these steps in the formation of judgments, it may be well to introduce a caution. Throughout the procedure of definition, classification, testing, and tabulation, great care must be taken not to form premature conclusions. Sometimes, when the facts are classified, the whole problem is reduced to such familiar elements that the solution becomes obvious and conclusions which have been previously drawn, or solutions which have been used before, may be used again.

In most cases, however, new elements are introduced, which make the conclusion doubtful or the solution uncertain. To jump directly from consideration of a few facts to a hasty conclusion, without giving inference a chance to operate independently, simply invites failure. This has been fully brought out in a previous chapter.

DEFINITION—ITS MEANING

To define means to set limits or bounds. Definition, therefore, specifies for any fact the group of facts to which it belongs and mentions the distinctive qualities which differentiate it from the other members of the group.

It is absolutely essential for the investigator to have a clearly defined general body of knowledge bearing on the matter being investigated. It is equally essential that the new facts coming into his experience be clearly defined, or otherwise their significance and bearing on the problem will not be readily seen. If he is at all doubtful about the real meaning of the data, now is the time to clarify his ideas, and definition is a most valuable aid in so doing.

While it is not necessary often to define the facts in writing, he should be able to define clearly, if necessary, any of the terms which he expects to use. Otherwise, he will have difficulty in presenting his conclusions in such form that they will be readily grasped by others.

RULES OF DEFINITION

In formulating clear ideas or conceptions of the facts observed, it will be found helpful to keep the following rules of definition in mind at all times:

1. Definitions should cover all items properly coming under the term defined and should exclude any not properly so included. This seems an obvious rule, but it is one which is frequently violated. To define the balance sheet as a financial statement is incomplete, inasmuch as there are other financial statements besides the balance sheet.

2. Definitions should be expressed, if possible, in language more clear and simple than the term defined. Sometimes this is difficult. Especially in the case of technical facts which require the use of scientific or unusual terminology in order to clearly establish the meaning. However, the writings of Huxley, Tyndall, and many other great scien-

tists, show that clear definitions, even of highly technical terms, are possible when the person defining the term has a fundamental grasp of that which is to be defined and a real effort is made to express their meaning in simple language.

3. Definitions should not employ the terms being defined either directly or by implication. To state that the balance sheet is a financial statement in which the assets and liabilities are balanced one against the other, while it is quite true, yet does not represent a good definition.

4. Definitions should be expressed in positive rather than negative terms. To state that a balance sheet is not an income statement does not add anything to the knowledge as to what it is. While this rule holds in most cases, yet there are some things which can only be defined negatively, since they themselves are negative facts or conditions. For instance, a mistake or an error can only be defined in a negative manner. This, however, does not make the definition any the less true. As a rule, however, most of our knowledge is of a positive character, and consequently calls for positive definitions.

5. Definitions should be as brief as is consistent with completeness in other respects. In the definition "a balance sheet is a statement of the financial condition of a business at a given time, in which the assets and liabilities of the concern are listed for comparative purposes, and which is usually prepared at the end of the fiscal period," the latter clause, although it is quite true, is unnecessary and consequently should not be incorporated in the definition.

When some new situation is met or some new fact comes into the experience which it seems difficult to define in view of a doubt as to the class or division of knowledge to which it belongs, it is often advisable and especially useful in describing observations to define by description. That is to say, the definition, instead of stating the exact meaning of the fact or observation, will describe its action in such a manner as to give a clear impression of its nature.

While this is permissible in the beginning of the work before the investigator has had an opportunity to organize his knowledge properly, yet with a greater mastery of the subject will come the ability to form more accurate definitions, which will better identify the facts or observation in question. For most purposes the best type of definition is one which refers an idea or fact to the fundamental factors involved, if possible, furnishing the means for reproducing the idea, if that should be necessary. Thus definition is inseparably tied up with classification, which will now be taken up for consideration.

CLASSIFICATION AND WHAT IT INCLUDES

The mind cannot grasp the full significance of miscellaneous isolated facts even when the meaning of each fact is clearly understood. Sound judgments and a full understanding of the relation of the facts to the problem only become possible when the facts are grouped or arranged in systematic order. This grouping or arrangement is called classification.

Perhaps the clearest and most complete definition of classification is that given by W. S. Jevons:[1] "By the classification of any series of objects is meant the actual or ideal arrangement together of those which are like and the separation of those which are unlike, the purpose of this arrangement being, primarily, to disclose the correlations or laws of union of properties and circumstances, and secondarily, to facilitate the operations of the mind in clearly conceiving and retaining in the memory the characters of the objects in question."

PURPOSE OF CLASSIFICATION

The purpose of classification is to disclose the range within which the facts operate. In so doing, classification

[1]Jevons, W. S., *The Principles of Science,* p. 677.

functions from two directions, the one analytical, the other synthetical. In the first, the procedure of classification is from the general to the specific, beginning with broad classes and subdividing these successively until all the facts have been assigned their proper place.

In the other type, the procedure is the reverse. Here starting with a number of isolated facts the procedure is to work backward from them to the broad general divisions, at the same time building an orderly system. Both methods produce the same results, the only difference being the point of attack. Both are subject to the same laws and may be applied to the same type of facts.

KINDS OF CLASSIFICATION

Classification may be of two broad kinds, artificial or natural. An artificial classification is one based upon externals, or what may be termed accidental properties. For example, the classification of the books in a library in accordance with the first letter of the author's name is an artificial classification.

A natural classification, on the other hand, is one which is based upon essential qualities inherent in the facts or observations classified. The division of the books in the library according to their subject-matter presents a natural classification.

Both artificial and natural classifications are valuable. While, of course, the natural classification will be the more scientific and probably the more accurate, yet it often happens that an artificial classification will serve a useful or practical purpose. When this is the case, it should be used, notwithstanding the fact that it may not be scientific. The test of the value of any classification lies in its usability, not in its beauty or symmetry.

How much need there is for classification depends on the nature of the problem and the variety of facts observed. In many cases the executive does not have to go far afield for

the facts on which to base his decision. From the memory of what was done on previous occasions or from information contained in the papers at hand, or furnished by subordinates, and so forth, he rapidly assembles sufficient data, classifies, tests, and tabulates it mentally, and in a brief space makes his decision.

At other times when the facts have been gathered from many sources, often by many hands, no adequate conception can be formed of their meaning or value until they have been carefully classified and summarized in the form of tables or charts. In doing this, considerable editing and interpreting of the facts may be involved, and when the conclusions have to be presented to others for acceptance, considerable tabulation, preparation of summaries, graphic charts, and so forth, may be advisable.

PROCEDURE OF CLASSIFICATION

The successful use, however, of all the steps subsequent to classification depends upon the care which has been taken in the grouping and arrangement of the facts. A thorough understanding of the procedure involved in classification and a knowledge of how to utilize it effectively is therefore essential.

This fact is most clearly brought out by Frank Cramer:[1] "Performed consciously or unconsciously, the act of classification is indispensable to and accompanies every scientific inference. A mind is orderly or slovenly, according as it does or does not habitually and accurately classify the facts with which it comes in contact. The success of an investigation, the worth of a conclusion, are in direct proportion to the fidelity to this principle and the exhaustiveness with which the process is carried out."

Classification is the culmination of the analysis which began with the collection of the facts. Although obviously

[1]Cramer, Frank, *The Method of Darwin: A Study in Scientific Method*, p. 88.

this cannot properly take place until a comparatively large number of facts have been gathered, yet in a certain measure it is used almost from the very beginning. As soon as a few facts are gathered, the investigator, unconsciously perhaps, groups them according to their apparent likes and dislikes. He realizes, of course, at the time that such groupings are only temporary and may later be subject to modification or change as additional facts are gathered. It is the only way, however, that he can refer his observations to the knowledge he already possesses so as to form a judgment as to their significance.

As a consequence, the preliminary steps of classification tie back into previous divisions of the investigational procedure. In order, however, that a thorough understanding may be had of the subject, it is advisable at this time to consider the process in its entirety. There are four distinct steps involved in classifying any collection of objects or facts, and these are as follows:

1. The selection of the basis for the classification;
2. The listing of the facts to be considered;
3. The formation of broad, general divisions based on outstanding attributes or characteristics;
4. The assembling of the facts under their proper divisions.

Of these four steps, the first two are preliminary, reaching back into a collection of facts and their subsequent listing and testing. What is properly the act of classification begins, therefore, with the formation of groups and ends with the assembling of facts under their proper divisions. All of these steps, however, are essential in order to make an effective classification, and, hence, we will now take up each separately.

1. *Select the Basis for the Classification.* Any assemblage of objects or facts can usually be classified in a number of ways, depending on the purpose for which the classification is prepared. For example, equipment may be classified by the accounting department on the basis of cost;

by the planning department on the basis of function; by the maintenance department on the basis of location.

In most cases the preliminary analysis discussed in Chapter III definitely establishes the general plan for carrying on the work and this, in turn, suggests the classification or grouping of the facts which is most desirable. Sometimes, however, although the purpose or objective of the work is quite evident, there may be some doubt as to the most advisable grouping of certain facts in order to accomplish the purpose in mind. For example, an engineer, in recording his observations, frequently has to choose between classifying them under the departments in which they were made or under the subject-matter itself.

At other times, when information of striking importance has been gathered through the medium of interviews or questionnaires, the question may arise as to whether it is best to classify this information under the persons from whom received or the subject-matter. When the persons furnishing the facts are authorities, it sometimes happens that the information can be most effectively used if it is classified according to the former method.

Otherwise, however, the obvious classification is according to the subject-matter. Both methods are used. The one represents the artificial and the other the natural. The only rule which can be given for choosing between them is to anticipate as nearly as possible the use which will be made of the classification, and group the facts in the most effective way to accomplish this purpose.

2. *Make a Complete Listing of the Facts.* It is not safe to start the real work of classification until a considerable number of facts have been gathered and carefully listed. As already noted, the investigator, almost from the beginning of his work, groups the observed facts according to their similarity, but this grouping is only of a temporary nature and must not be confused with the deliberate classification which now takes place.

The listing of the facts should be as complete as possible,

for the omission of even one essential fact may destroy the value of the classification. In cases where it is not practicable to list all the facts, particular care must be taken to make sure that all the representative facts have been included.

For example, in the classification referred to in the previous section, failure to list one item of equipment would seriously affect its accuracy if that item were the only unit of its kind, whereas but little difference would frequently result if it were but one of a numerous group, the remaining members of the group being listed.

3. *Form Broad, General Divisions*. If the facts have been carefully defined, the investigator has an accurate knowledge of their characteristics, and his next step is to group them into certain broad classes or divisions based on their inherent qualities. Only fundamental characteristics are considered in making this primary grouping, no attempt being made at this time to account for minor differences.

The writer, for example, in working out a classification of factory equipment, found it advisable to group equipment according to the following primary divisions:

(*a*) *Machine tools,* consisting of fixed equipment working directly on the product;
(*b*) *Tools,* consisting of jigs, fixtures, and other accessories, working directly on the product, or auxiliary to machine tools, but not fixed by location;
(*c*) *Power plant,* consisting of all equipment contributing to the generation of power;
(*d*) *Transmission,* consisting of all equipment used for transmitting power;
(*e*) *Mechanical handling,* consisting of permanently built-in equipment for material handling;
(*f*) *Transporting,* consisting of movable equipment for handling materials;
(*g*) *Measuring,* consisting of equipment designed to measure, count, weigh, and so forth;
(*h*) *Office,* consisting of desks, chairs, tables, and various equipment used for clerical work;

(*i*) *Miscellaneous and compound equipment,* consisting of all types which did not fit directly into the previous classes.

After the main divisions have been formed, the same process of inspection is applied to the facts coming under each division, and these are subdivided further into smaller groups based on inherent qualities. And this process is continued until the facts are classified as closely as the problem demands. As an excellent example of a classification running into many divisions, see the Dewey Decimal Classification, a copy of which may be found in almost every public library.

LAWS OF CLASSIFICATION

In order to insure accuracy in forming these divisions and subdivisions, it will be helpful for the investigator to master thoroughly the seven laws of classification, which are:

(*a*) The classification must serve a useful purpose.
(*b*) There must be no change in the basis throughout its extent.
(*c*) It must include all the facts to be considered.
(*d*) Each division must be mutually exclusive of every other division.
(*e*) Simple and natural groupings are preferable to complex.
(*f*) The order assigned to the divisions must be natural and logical.
(*g*) Provision must be made for flexibility.

A classification is a means to an end—not an end in itself. Therefore, the first law is concerned with its utility. There is no gain or benefit derived from making classifications which do not serve a useful purpose, no matter how interesting the grouping of the facts may be.

After the basis has been once selected, there must be no change throughout the extent of the classification. Every subdivision must carry forward the same purpose as prompted the primary groupings of the facts. For example, function was the basis selected for classifying the equipment referred to on a previous page. If in any of the sub-

divisions, the grouping had been on any other basis, the classification would not have accomplished the purpose for which it was prepared.

Every fact that is retained as pertinent to the investigation must find a place in one or another of the divisions. If there is found one fact for which a place cannot be found, the divisions are insufficient, and others must be formed.

Not only must the divisions include every fact, but each must be mutually exclusive of every other division. In other words, the lines of distinction between divisions and between subdivisions of equal rank must be so clearly drawn that the proper position of any item is evident. No classification is thoroughly practical in which the divisions are so loosely defined as to allow overlapping or doubt as to the proper position of an element.

As the purpose of a classification is to establish order and to fix the identity of the facts, it follows directly that the simpler and more natural the groupings, the greater the ease in using it to accomplish the desired purpose. Complexity not only makes it harder to classify the facts, but also increases the difficulty of understanding their true meaning and relationship.

The order or arrangement of the divisions should be logical or designed to emphasize the purpose of the classification. When there is a choice between several methods of grouping, each of which possesses several advantages, select the one which is easiest to follow. When there is no outstanding logical or natural order, it is often advisable to arrange the facts alphabetically, or according to their numerical value.

In every classification provision of some sort must be made for flexibility. Additional facts are bound to come up, and if the classification is not sufficiently flexible to include these facts, some, and perhaps all, of the work of forming the divisions will have to be done over. A good way to provide for flexibility is to have one division which is sufficiently elastic to accommodate facts of the utmost

diversity. For example, in classifying animals as vertebrate or invertebrate, the latter represents a flexible group to which any animal can be classed which is not a vertebrate.

As the facts grouped in this "miscellaneous" division become numerous and sufficient similarities can be noted to make possible a further grouping of these elements, additional divisions or subdivisions may be formed of any category, since there is no limit to the number of groupings that may be formed, provided the other rules of classification are observed. At the same time, care must be taken to keep these unclassifiable items at a minimum. When they are at all numerous, it is usually because the basis is wrong or because essential facts have not been secured.

Opinions, reasons for doing certain things, details, experiences, are difficult to classify. However, usually certain similarities can be discovered which enable a classification to be made. One practical way is to group conclusions together and classify numerically. In such cases, however, care must be taken to classify the opinions of various classes together, experts separate from consumers and dealers, and so forth.

The effectiveness of any classification, either of facts or objects, can be accurately determined by testing its divisions by these seven laws.

4. *Assembling the Facts.* The practicability of the work of classification thus far is established by assembling the facts under the divisions which have been formed. In ordinary business problems this does not offer any serious difficulty. The facts form themselves readily into a few easily distinguishable groups and comparisons can often be made mentally.

When, however, the facts are numerous or diverse in character, it is necessary to use certain mechanical means of assembly, depending on the nature and character of the facts. A loose-leaf notebook is often used and is of especial value in assembling personal observations and notes taken while reading books and magazine articles, or when

conversing with others. In this book, sections are reserved for each division, and the data are filed in these sections.

When the observations and notations are numerous, or it is desired to assemble clippings, reports, pamphlets, and so forth, for future use, the notebook becomes inadequate and the best plan is to use an ordinary correspondence file. Folders are provided for each division and for important subdivisions, and the data are filed in these folders.

One industrial engineer has worked out a very complete system for assembling observations made during the survey of an industry. Based on previous experience he has found that surveys of this character fall into certain logical divisions, such as engineering, purchasing, receiving, storing, equipment layout, personnel, and so forth.

In order to ascertain the cardinal facts regarding each of these divisions, he has prepared certain salient questions. The general procedure is to take up these divisions one at a time, though not necessarily in any particular order. The information called for by the questions is first obtained and then the additional facts are gathered, which are suggested by the preceding; and these observations, together with any explanatory information which seems to have a bearing on the problem, are then filed under the proper divisions.

In assembling the information collected during a market survey, a similar method may be used, the data in this case being filed under the general divisions of the work, such as:

(*a*) The product to be marketed
(*b*) The company
(*c*) The industry in general
(*d*) Competition, and so forth

These are only examples; no hard and fast arrangements can be recommended. Each investigator must make his own classification to fit the requirements of his own particular problem, and assemble the facts accordingly. Simplicity, accuracy, and utility are criteria which in the final analysis determine its value.

RECAPITULATION SHEET

Another means of assembling the facts is the recapitulating sheet. It performs the same function as a "tally" sheet, and is most frequently used in assembling information of a categorical nature obtained from interviews or questionnaires. In addition, it can also be used to visualize such of the information contained in notebooks and folders as it is possible to condense into simple terms.

The recapitulation sheet assumes many forms, depending on the information to be assembled. In general, however, it lists along one side of the sheet various items of information which are desired, and along the other side sources from which the information is secured. At the intersection is entered the reply which has been received.

For example, not long ago a large commercial establishment employing over 700 clerks was planning a new office building. Desiring to profit from the experience of other concerns, questionnaires were sent to office managers of 50 selected establishments asking for the following information:

Name of Firm Date......................

1. What is the average number of square feet of working space (exclusive of private offices) per office employee?...................Ft.
2. How much space do you allow?............................Ft.
   (*a*) For width of interior aisles?...........................Ft.
   (*b*) In front of files frequently consulted?...................Ft.
   (*c*) Between rows or banks facing one direction?.............Ft.
   (measure from front of one desk to back of next desk)
3. Do you favor the large open office plan or the private office?.......
4. Is there any distinction made between high and low officials in regard to use of private offices, and if so where is the dividing line drawn?
   ....
   ....
5. Would you in any case give private offices to managers who must closely supervise operating departments?........................
6. (*a*) What type of office partition is in use in your office:
   Solid plaster or tile..........Wood and glass..........Plaster and glass...........
   (*b*) What kind of glass is in use..........Clear glass..........
   Florentine...........

7. What kind of office illumination have you?........................
   (a) Direct.......... Indirect.......... Semi-indirect...........
   (b) Make of fixture..
   (c) Height of fixture from floor..................................
   (d) What is the size of bay?.......... (e) How many fixtures to bay?.........................
   (f) Are fixtures hung in straight rows or staggered?.............

8. Do you use mechanical ventilation?..............................

9. (a) What method do you use in taking care of employees' hats, coats, umbrellas, and so forth?....................................
   (b) Which do you think is preferable for a clerical force of about 1,000 people, a centralized checkroom for wraps (one for men, one for women) in charge of one or more attendants, or groups of individual lockers placed adjacent to working quarters?.... ....
   (c) If you use lockers, what type do you use, and is one locker assigned to more than one individual?.....................

10. (a) Do you have a restroom for women clerical workers?..........
   (b) If so, what is its size?............. (c) Number of women workers?................ (d) What restrictions do you place on use of restroom during office hours?.....................
   (e) Do you have a smoking-room or club-room for men?........
   (f) If so, what is its size?................ (g) Number of male employees?.....................

11. Do you use "Diffuselite" blinds?............ If so, what is your opinion of them?...

12. (a) Do you have an employees' cafeteria?.......................
   (b) If so, is the food furnished at cost, below cost, or do you endeavor to make a profit?................................
   (c) Are your employees required to eat in the cafeteria?.........
   (d) What efforts do you make to prepare meals that are balanced from a dietary standpoint?...............................
   (e) What attempt, if any, is made to induce employees to select sensible foods?......................................

Remarks:

Thirty-five replies were received of which 30 came in shape to use. In Figure 6 is shown a recapitulation of these 30 replies. This information being gathered in confidence, firms replying are indicated on the sheet by number instead of names.

It is a good plan to draw up the recapitulation sheet early in the investigation. When using questionnaires for collecting information, there is a decided advantage in preparing it at the same time as the questions are formulated. It thus acts as a check on the adequacy of the questions,

and forces rewording in many cases so that the replies may be assembled economically.

Ordinarily it is a good plan to enter the information on the recapitulation sheet as it comes in, but this is not essential. In many instances circumstances of time and available clerical help may make it necessary to postpone the entry until a considerable volume of information has been gathered. If this, however, is put off until late in the investigation, insufficient opportunity is given for gathering additional information along those lines where the facts are obviously inadequate.

Cards are often valuable for assembling data because of their flexibility. The size 3 by 5 is most frequently used. The investigator notes the facts observed promptly on the card, sticks it in his pocket and files it later under a suitable division. In this way information of a miscellaneous character, figures, ideas, suggestions, and so forth, may be assembled for later use. In using this system, put but one item of information on a card and provide sufficient guides so that the material may be visualized as fully as possible. It is also advisable to make cross-references for such material as may be used for more than one purpose.

But for extended investigations, especially where questionnaires are used, the card system is not as practicable as the recapitulation sheet. One exception, however, is the case where it is desired to keep the information in permanent form, either for future reference, or because the same sources will be used again and it is desired to make comparisons of the data obtained from time to time. For this purpose the card system is ideal.

It does not matter whether the subjects to be classified are objects or ideas. If the four steps above outlined are closely followed, a classification can be prepared which will be of practical value. While the preceding outline indicates clearly the steps involved, a still better understanding of the procedure of classification may be had if an actual example is described.

Firm	*1	2(a)	2(b)	2(c)	3	4	5	*6(a)	6(b)	7(a)	7(b)	7(c)	7(d)	7(e)	7(f)	8
1	Sq ft 40	Ft 5½	Ft 6	Ft 6	—	All Executives and Dept Hds	Yes-With Clear Glass Partitions	Wood and Glass	Both	Semi-Ind	Brasco Lite	Ft —	Ft —	—	Straight	Yes
2	—	—	No Uniformity	3½	Open	—	No	Plaster and Glass	Clear	Semi-Ind	—	Against ceiling	16	One	Straight	No
3	50	6	4	6½	Open	—	Not ordinarily	Wood and Glass	Frosted	Ind and Semi-Ind.	—	Ind 3' from Ceiling	Varies	—	Staggered	No
4	55	4 to 6	3 to 6	3 to 4	Open Except for Exec or Confident. Work	None	No	Wood and Glass	Clear	Semi-Ind	Brasco Lite	12 to 15	18 to 20	One	Straight	No
5	25	2½	4	2½	Open	No Sharp Lines	No	All three	Clear	Ind and Semi-Ind.	—	—	18	1 to 3	Straight	Yes
6	30	5	—	3	Open	Supt or Mgr	No	All three	Both	Semi-Ind	—	About 10 Ft	16	One	Straight	Yes
7	40	3	3 to 5	3	Open	—	—	Wood or Plaster and Glass	Both	Semi-Ind	Nat'l X-Ray	About 10 Ft	20x20	4	Straight	—
8	35	4 to 6	4 to 6	4	Open	—	—	Solid Plaster Steel and Glass	Clear	Semi-Ind.	—	Varies	17 on center	4 x 5	Straight	—
9	50	5	—	3½	Open	—	No	All three	Both	Each type	—	—	15	—	Straight	No
10	—	3	3 to 5	3	Open	Officials and Executives	Only When Necessary	Wood and Glass	Clear	Semi-Ind	Denzar	8	19x19	4	Straight	Partly
11	25	2 to 3	3	3½	—	—	No	Wood and Glass	Flor	Semi-Ind	—	10	—	—	Straight	No
12	—	12	6 to 8	4½	Depends on Depart.	—	No	Wood and Glass	Clear	Semi-Ind	Brasco Lite	11	15x18	One	Straight	No
13	—	3½	—	2⅔	Prefer Open	—	No	Wood and Glass	—	Ind and Semi-Ind	Prefer X-Ray	—	—	—	Straight	Yes
14	35 to 50	3	4½	3	Open for Each Dept	—	No	Wood and Glass	Flor	Ind	Special	—	—	—	—	No
15	—	2½	5	8	Open Plan For Gen Wk.	No Distinct Line	No	Plaster and Glass	Flor	Ind	X-Ray	10	18x18	3	Straight	No
16	36	3¼	3	4	Open	Yes	No	Wood and Glass	Clear	Direct	—	9	20	One	Straight	No
17	25	2½	3	2½	Open	—	No	Wood and Glass	Clear	Semi-Ind.	—	—	12	One	Straight	No
18	70 to 100	2 to 4	3 to 5	2½ to 3½	Prefer Open	No	No	All 3	Both	Semi-Ind	Phoenix	10½	Varies	Varies	Straight	No
19	—	5	6	—	Private	Dept Mgrs	Yes	Solid Plaster or Tile	—	Semi-Ind	—	11	—	—	—	Yes
20	40	3	8	5	Open for Depts.	Dept Heads	Yes-with Clear View of Dept.	All 3	Clear	Direct	—	8½	—	—	Straight	No
21	75	3½	5	3½	Open	Sr. Exec Officers	No	—	Flor	Semi-Ind.	Duplex-Elite	8	—	One	Straight	No
22	50	7½ to 10	4 to 5	5 to 6	Open	Pres and Vice-Pres Only	No	Wood and Glass	Flor	Direct	—	9	225 Sq Ft.	Four	Straight	No
23	—	6	5	5½	Open	—	No	Wood or Plaster and Glass	Both	—	Phoenix	11	20 x 23 20 x 28	4 and 6	Straight	No
24	156	5	6	5	Don't Favor Large Open Office	—	No	Wood and Glass	Clear	Ind	Duplex-Elite	8	—	Apportioned by Engineer	Straight	Yes
25	—	3	—	2½	Open	Executive Officers Only	No	Wood and Glass	Clear	Ind	—	—	—	—	—	Yes
26	75 to 100	3	1½	2 10"	Open	Head of Major Division	No	Tile With Glazed Sash	—	Direct	—	10½	16x16	One	Straight	Very Seldom
27	100	4½	5	4½	Open for Clerical Force	Dept. Hds. and Staff Officers	Yes- to General Auditor	Wood and Glass	Clear	Semi-Ind.	Ivanhoe	9	—	—	Straight	Yes
28	36	3⅓	6½	6	Open-General	—	Never	Tile and Glass	Chipped	Semi-Ind.	Duplex-Elite	—	15 x 38	4	Staggered	No
29	—	2½	5	4	Depends on Nature of Work	—	No	Solid Plaster Wood and Glass	Both	Semi-Ind	Sterling	9	17½ x 28½	2	Straight	In Clk Room Only
30	—	5	4	4	Open-Pri Offices for Execs	Depends upon Duties	Semi-Private	Wood and Glass	Clear	Semi-Ind	Brasco-Lite	11	15 x 15	One	Straight	No

Firm	9(a)	9(b)	9(c)	10(a)	10(b)	10(c)	10(d)	10(e)	10(f)	10(g)	11	12(a)	12(b)	12(c)	12(d)	12(e)
1	Separate Locker Rooms	Individual Lockers	Single Lockers	Yes	Sq ft 624	75	10 Min. morn. and afternoon	Yes	Sq ft 1200	113	No	Yes	—	No	None	Bulletins and talks by Medical Dept.
2	Steel Lockers	Central Room Best	Fed Steel 4 Men or 6 Girls to Locker	No	—	—	—	—	—	—	No	No	—	—	—	—
3	Costumers and Cloak Rooms	Lockers	Do not use	Yes	525	75	Room in Charge of Personnel Secretary	No	—	—	No	No	—	—	—	—
4	Coat-Racks in Ante-Rooms	Central Check Room	Do not use	Yes	1000	200	Matron Responsible	No	—	—	No	Yes	Below Cost	No	—	—
5	Locker Room	Central Check Room	Expanded Metal. 2 Per. to locker	Yes	10,000	1000	Super. by Capable Woman	Yes	1500	2000	No	Yes	Cost Without Overhead	No	—	—
6	Cloak Room	Central Check Room	Do not use	Yes	1728	1150	Nurse's O.K	Yes	1200	1250	No	Yes	Loss	Forbidden to eat in Plant	Doctor Consulted	Company Magazine
7	Costumers	Lockers or Costumers	Not used	Yes	864	450	—	Yes	1800	500	No	Yes	At Food Cost	No	Controlled by Supervisor	—
8	Lockers	Groups of Lockers	Indiv for Men – 3 women to Locker	Yes	Small	—	Nurses or Doctors Approv.	No	—	—	No	No	—	—	—	—
9	Coat Racks or Costumers	Central Check Room	—	Yes	400	82	—	Yes	—	100	No	No	—	—	—	—
10	Clk Rooms in or Near Dept	Central Check Room	Not used	Yes	2200	450	Silence Room Only Dur. Office Hrs	No	—	—	No	Yes	Cost No Overhead Charged	No	Judg. of Well-Paid Chef	None Except Plain Menu
11	Steel Lockers	Lockers on each Floor	—	Yes	500	—	—	Yes	360	—	No	Yes	—	—	—	—
12	Lockers and Costumers	Lockers	Lyon- 2 Persons to Locker	No	—	—	—	—	—	—	No	Yes	Below Cost	No	None	None
13	Lockers	—	Steel Locker 2 Persons to Locker	Yes	—	—	—	Yes	—	—	No	Yes	At Cost	No	Menu Prepared by Dietician	—
14	Lockers	Lockers	Steel 4 People to Locker	Yes	1000	2300	Permit from Dept Hd	Yes	400	700	No	Yes	Below Cost	No	—	—
15	Clk. Rooms and Some Lockers	Lockers	Locker for Each Person	Yes	500	220	None	No	—	—	Yes Very Good	No	At Cost	No	—	—
16	Steel Locker	Lockers	Steel Locker for Each Person	Yes	320	188	—	No	—	—	—	Yes	Loss	No	Menu O.K'd by Doctor	—
17	Central Room	Central Room	—	Yes	—	—	Nurse in Charge	No	—	—	No	Yes	Cost	No	—	—
18	Lockers	Individual Lockers	Steel Lockers	Yes	2125	185	Noon Hr Only	Yes	738	115	No	No	—	—	—	—
19	Locker Rooms	Individual Lockers	Metal	Yes	320	30	None	Smoke in Lunch Room	—	100	No	Yes	Below Cost	No	None	None
20	Cloak Room for Each Dept	Cloak Rooms	Lockers Unsatisfactory	Yes	4,550	369	Nurse in Charge	Yes	—	—	No	Yes	Lunches Furnished Free	No	—	—
21	Hat Trees Adjacent to Work Quarters	Individual Lockers	Do not Use	No	—	—	—	No	—	—	No	No	—	—	—	—
22	Locker Rooms	Central Locker Rooms	Wooden Lockers	Yes	1000	300	Allowed 10-15 min A.M. & P.M	No	—	—	No	Yes	At Cost	No	—	—
23	Locker Rooms	—	—	Yes	1500	300 – 400	Attendant Reports to Dept Head	Yes	255	71	No	Yes	At Cost	Cannot Eat Lunches in Office	Judg. of Mgr. and Doctor	Bulletins Diets Recommended
24	Lockers	Individual Lockers	Lyon—Locker for Each Person	Yes	2394	350	Used in Lunch Period Only	Yes	2394	110	No	Yes	Below Cost	No	None	None
25	Lockers for Women Coat Rooms for Men	—	H&H Metal 2 Persons to Locker	Yes	768	160	10 Min Allowed Twice a Day	No	—	—	No	No	—	—	—	—
26	Steel Lockers	Locker Rooms Preferred	Steel-Individual Lockers	Yes	—	—	Reasonable Supervision	—	—	—	—	—	—	—	—	—
27	Lockers	Central Check Room	Steel-Individual Lockers	Yes	300	35	Dept. Hds. Responsible	No	—	—	Yes	In Factories only	At Loss	No	Sug. from Nurse followed by Chef	None
28	Clk. Room and Lockers	Lockers	Hart & Cooly 1 for 2 People	Yes	270	32	To be Used in Case of Sickness	No	—	—	No	Yes	At Loss	No	—	—
29	Central Check Room	Central Check Room	—	Yes	950	120	Pass from Dept Manager	No	—	—	No	Yes	At Cost	Yes	Mgr. of Cafeteria is Dietician	None
30	Lockers	Lockers	Durand-Steel 1 for Each Emp.	No	—	—	—	No	—	—	No	Yes	At Loss	No	Exp. Cook in Charge	None

Figure 6: Recapitulation of replies received to questionnaire given on page 198.

In one large concern it had been the practice for each manufacturing department to maintain its own stock of such materials and supplies as were used by it, the foreman being responsible for maintaining the stock.

Since some materials were used in a number of departments, the annual inventory always showed an excessive investment in many items. Notwithstanding this fact, shortages of materials were frequent, resulting in broken schedules because the foremen, pressed by other duties, would forget to order necessary materials in time to meet the schedule.

The management became convinced that these unsatisfactory conditions could only be eliminated through installing an efficient stores system, and an industrial engineer was employed for that purpose. After making a careful survey of the job, he found that he must first of all make a classification of the materials and supplies which were used in the various departments, and this is the way in which he worked out his classification:

1. He first of all definitely established the basis upon which the materials were to be classified. In so doing he had to choose between classifying them according to the purpose for which they were to be used (artificial), or according to their nature (natural). He chose the latter as being the best for his purpose in this instance because of the fact that most of the materials were used on a number of products.

2. A thorough investigation was made of the materials and supplies stored in the different departments and it was found that these included a miscellaneous assemblage of items running into the hundreds. These items were listed and a careful description was made of each showing the shape, size, weight, and other characteristics which might be of service in determining not only its position in the classification, but also its location in storage.

3. This careful study of the characteristics of the mate-

rials brought out the fact that there were a number of broad, general classes into which these items would be naturally grouped, and the following divisions were formed:

Office supplies	Liquids, lubricants, and paints
Brass, bronze, and pipes	Engine, boiler power
Coal, coke, and fuel	Iron pipes and fittings
Belts, hose, rope, and twine	Steel and iron
Electrical supplies	Tools, implements, and supplies
Fastenings, bolts, and screws	Building materials
Gears	Abrasives
Hangers, pulleys, and clutches	Wood
Gaskets and packing	Otherwise unclassified
Chemicals	

4. The materials were then arranged according to these main divisions, and in order to simplify the recording, storage, and handling still further, these divisions were subdivided into groups depending upon the qualities of the materials contained in them. For example, the following is the way in which "fastenings, bolts, and screws" was subdivided into bolts, wood screws, nails and spikes, cotter pins, lag screws, expansion sleeves, machine screws, snaps, nuts, staples, rivets, set screws, fasteners, draw lugs, washers, tacks, and studs.

All the items of materials and supplies having been classified, it then became possible to arrange for storage space which would take care of each most effectively. A place was assigned for each item where all materials of that kind were stored and these places were arranged so that they could be easily reached.

A stock card was made out for each item on which a record was kept of quantity in stock, amount on order, withdrawals, allotments to orders but not yet withdrawn, and balance on hand.

Under the previous method no one knew until an inventory had been taken how much of any kind of material there was on hand, nor its exact location. Under the new system information was available instantly showing the

exact quantity in stock, and it was possible to locate and withdraw the materials in a few minutes.

The results accruing were a radical reduction in material shortages, combined with an 18% reduction in inventory. The effective classification of materials largely made these results possible.

SUMMARY

The forming of sound and reliable judgments about the observed facts constitutes the third step in the investigational procedure. In forming judgments four distinct operations are involved, which are closely related and mutually dependent upon each other. The first of these is definition, the purpose of which is to clearly establish the meaning of the facts, and the second is that of classification, which has for its purpose the systematic arrangement of the facts.

Every step in the investigation of any subject involves classification. One of the most important mental powers is that of detecting identity, and classification is simply the placing of things together in such a way that their identity can be detected. Consequently, classification forms the basis of inference and reasoning. Some one has said that "classification is the beginning of wisdom" but not only is this true but it may almost be said to be the end of human knowledge.

With a clear understanding of definition and classification, the third and fourth operations, which will be concerned with testing and interpreting the facts and tabulation and presentation, can now be taken up for discussion.

XIII

TESTING AND INTERPRETATION

Purpose of editing collected data. Procedure of testing. Is there evidence of prejudice or bias? Are the facts pertinent and essential? Are the facts representative in character? Are the facts accurate and reliable? Is the collection of facts sufficiently comprehensive? Are the facts comparative? Other tests.

WHILE the facts are being assembled the opportunity is afforded for a more careful testing than has been possible before. Without reflecting in any way on the value of the preliminary tests, which were applied to the facts as they were gathered, these must give way in importance to the deliberate and reflective testing which occurs when they are being assembled and before they can be properly tabulated.

The preliminary tests were of necessity limited to consideration of each fact, individually. Because of this limitation, many facts could not be fully verified at the time they were gathered, but had to be accepted at their face value and checked up later. Statements made in interviews, replies to questionnaires, are cases in point. Until sufficient data have been collected and classified, the accuracy and real value of this information cannot definitely be known.

The procedure involved in testing the facts is primarily analytical in character. In many instances, however, especially where statistical information has been gathered from many sources, an additional function is involved—that of interpretation or editing, which is designed to make such changes in the data as will prepare them for more effective tabulation.

In performing this analysis and interpretation, quite dif-

ferent qualities are called for, on the part of the investigator, from those required in collecting the facts. Judgment and discrimination are constantly demanded, not only in determining as to the acceptance or rejection of the facts, but also in ascribing to them their proper degree of importance.

In testing the facts, one group should be taken up at a time for consideration and the following tests applied to each, both individually and collectively:

1. Is there any evidence that prejudice or bias has developed during the collection of the facts?
2. Are the facts pertinent and essential?
3. Are they representative in character?
4. Are they accurate and reliable?
5. Is the collection of facts sufficiently comprehensive?
6. Are the facts comparable?

No matter how carefully the facts may have been gathered, the application of these tests will, almost always, reveal many cases where the data are partially or wholly unreliable. When time and opportunity afford, additional facts should be gathered bearing on such doubtful points so that they may be clarified absolutely.

Not always, however, is this possible or practicable. The investigator, in most cases, has already consumed considerable time in gathering the data, and he is desirous of bringing his work to a speedy conclusion. In other cases, especially in extended investigations, the doubtful information may have been secured through interviews or questionnaires, and it will be difficult, if not impossible, to secure further information at this late date.

Sometimes the facts may have to be thrown out, and this, perhaps, is the best thing to do if they cannot be corrected. In other cases where there are obvious errors due to misunderstanding, misinterpretation, bias, or errors in figuring, it is often possible, through careful editing, to so modify or correct the information that it can be used.

It is, however, relatively easy to distort the truth or

materially change the nature of facts by slight changing. Undue tampering with the data must, therefore, be avoided, and changes or modifications made only when the facts are obviously wrong. This editing can rarely be done properly by the same person who collects the data. In most cases it should be in the hands of his superior or a special analyst who is experienced in the subject and knows how to do this properly.

1. IS THERE ANY EVIDENCE OF PREJUDICE OR BIAS?

The importance of beginning investigational work with an open mind has been stressed before and scarcely needs repetition at this time. Often, however, the investigator will start out on his work in the proper frame of mind, or at least with a realization of the strength of his opinions, but gradually as he gathers the facts he becomes prejudiced, especially when they seem to point to a certain conclusion.

A common example is that of the field man sent out to interview a number of dealers. Starting out perhaps with no personal opinions on the subject, the information secured from the first few interviews may seem so overwhelming in favor of certain conclusions, that he forms a judgment before he has gathered sufficient information upon which to properly base it. This bias, early formed, unconsciously influences his mode of handling the subsequent interviews, so that instead of being designed to secure the real facts, they will often shape themselves into an effort to verify the hasty conclusion he has reached.

The team leading the National League on the first day of June may or may not be leading at the end of the season. For the same reasons, conclusions cannot properly be drawn in regard to the data, until the collection of the facts is sufficiently complete. It is, therefore, essential that the first test to be applied is one which is calculated to measure as closely as possible the influence exerted by prejudice.

It is realized, of course, that it is hard for any one to

test (with any great degree of accuracy) the facts that he, himself, has gathered. Especially is this true in attempting to estimate the influence of prejudice or bias, and that is one of the main reasons why it is recommended that a superior executive or a special analyst check over the facts before they are tabulated. The fresh view-point and broader perspective, brought to bear upon the problem by such inspection, is bound to lay bare any glaring errors due to bias, so that they can be corrected before it is too late.

In those cases where the investigator must check his own work, it is essential that he stop at this time and examine himself carefully to see how much bias or prejudice is reflected in his observations. In this connection it will be well to reread the section on "prejudice and its elimination," in Chapter V. The practical suggestions given there will be helpful in estimating to what extent the facts have been influenced in this way. Then it is possible to edit or modify them sufficiently for practical purposes.

Not only must the investigator look out for bias on his own part, but he must be prepared to note when it is present and influences the information that has been given him. Sometimes the extent of this prejudice can be readily estimated and proper allowance can be made for it in editing. At other times, while present, its extent and influence are unknown, and the information becomes uncertain in value.

Considerable judgment and discrimination must be exercised in editing the facts in all cases. Sometimes the extent of bias can be ascertained by applying other tests in combination. For instance, an investigation was made of a number of retail stores, in order to find out the percentage of overhead proper to allow for clerk hire. Very quickly it was seen that there was a tendency on the part of many proprietors to overstate the number of clerks they employed. By checking the data received with other information obtained, showing the number of clerk hours, a satisfactory check was secured and the information was edited so that it could be used.

2. ARE THE FACTS PERTINENT AND ESSENTIAL?

In applying this test it will be helpful to ask regarding each fact: "What is its real meaning and significance?" Too much emphasis cannot be placed on the necessity of knowing exactly what the facts mean. The rules for definition have been given in the previous chapter. The procedure involved at this time, therefore, is simply that of verifying the meaning which has been given to the facts at the time they were gathered and classified.

Through definition, often a considerable number of facts will be automatically eliminated from further consideration, and the relationship to the subject of those facts, which are retained, will stand out more prominently.

Other tests designed to bring out the pertinency of the facts are the following: What definite relation do they bear to the subject? Is the relation direct or indirect? If direct, is its influence sufficient to justify its retention? These and other questions of a similar character will bring out the pertinency of the information, and pave the way for its most effective utilization.

Perhaps since the investigation started there has been an occasion to modify the objective, or, perhaps, there are other points of view which were not considered in planning the procedure, yet which should be taken into account. Sometimes these new angles or points of view aid greatly in testing the adequacy of the judgments which have been formed.

Through the application of this test, the irrelevant facts are promptly disclosed and eliminated from further consideration; the indefinite character of certain facts is exposed; and the opportunity is afforded of either rejecting the data or editing them so that they become of service.

3. ARE THE FACTS REPRESENTATIVE IN CHARACTER?

It is impossible and quite unnecessary in most investigations to gather all the facts. Especially where there is a

large volume of information available, it is quite sufficient to study carefully certain representative facts and to formulate judgments from their consideration. When the purchasing agent wants to check up on the coal being delivered on a large contract, samples are taken from different cars or sections of cars and analyzed. If this sampling is representative, the average analysis will be sufficiently accurate to use as a basis in deciding as to the merits of the entire shipment.

This type of collecting information is known as "sampling," and is widely used in almost every type of investigational work. Although of great value in saving time, care must be exercised in order to make sure that the facts selected are representative in character. Samples taken from the top of the car might average considerably different in B.t.u.'s than if the selection were made from the bottom of the pile. The same is true of samples taken from the interior or exterior.

Do the facts represent normal conditions? Is any undue significance attached to exceptional instances? In the investigation of irregularities especially, it is only too easy for one to lose his perspective and to attach too great importance to the irregularities being studied. The importance of the isolated cases coming to his attention is magnified, and he gets a distorted view of operations and conditions.

Naturally, business judgment cannot be based upon abnormal conditions. It is true that the study of abnormal conditions often leads to great discoveries, but only when their real significance is understood. Care must be taken to distinguish between those facts which are only transitory in their relation to the subject, and those which exercise a controlling influence.

In making time studies, it is frequently advisable to throw out certain times, on account of their wide variation from the normal. At other times more can often be learned from consideration of exceptional times in determining

standards than from consideration of what seem to be normal times. Numerous other instances could be advanced, showing the necessity of making certain that facts admitted are representative in character.

If the facts are not truly representative, bias enters and errors are bound to occur. When it becomes apparent that the facts are not truly representative, one of two courses is open, either to reject them entirely or to gather additional facts which are representative. If time does not permit of doing the latter, it is frequently advisable to throw out the suspected facts entirely. Sometimes, if the experience of the investigator is sufficiently broad, he can edit them so as to make them usable, but this is a difficult and dangerous task and is not to be recommended.

4. ARE THE FACTS ACCURATE AND RELIABLE?

When the facts can be tested mechanically or mathematically, extreme accuracy can be secured. Some of the data may be in the form of maps, charts, or graphs. When this is the case, test by the general principles of construction. It takes only a slight manipulation of a figure or curve to show the facts in quite a different relation from the true state of affairs. It takes only a slight mistake in computing an average or preparing a summary to lead to an entirely erroneous conclusion.

Most business facts are relative, however, and their accuracy can be determined within limited boundaries. Even then it is practical, rather than absolute accuracy which is desired, and its degree is determined by the nature of the problem. It must be remembered at all times, that the cost of doing the work increases rapidly in proportion to the degree of accuracy insisted upon.

Are the facts consistent with other data? How do they check up with previous experience? From what sources is the information secured, and what is the reliability of these sources? What type of errors are present, and what is

their influence? These and other questions of similar import will suggest themselves in accordance with the character of the investigation. Many times the information comes in such an inadequate form that a considerable amount of editing is necessary, even when the foregoing tests are satisfied.

The facts may be tested for consistency in many ways. Previous experience may be utilized, or the facts may be compared with others of similar type gathered from other sources. Personal observations may be checked with the experience of others, and information secured from secondary sources may be verified by personal experience in addition to the preliminary tests suggested in Chapter VI.

In cases where the facts have been secured through interviews and questionnaires an internal check is frequently desirable. Such information is, as a rule, given hurriedly, often without considering fully its import. Errors therefore, readily occur which can only be caught and corrected by checking the replies against each other.

This internal checking is greatly simplified when "check" questions are inserted into the "interview" or "questionnaire." In fact, when considerable numerical data are required, it is desirable to ask both for totals and details so that these may be balanced against each other. Besides promoting accuracy, such questions are a help to the person supplying the information. Extensive checking of this type is confined largely to statistical researches, and in the usual type of investigation all that the investigator needs to do is to make such obvious tests for consistency as become apparent from the careful comparison of the various facts. But in either case, the errors he will locate and which will need correction will usually be of two kinds, known as compensating or cumulative errors.

Compensating errors are those which tend to self-correction. That is, the mistakes are of such a character that there is apt to be as much on one side of the scale as on the other. Ordinarily, when the facts are representative

and sufficiently comprehensive, this error will not assert a great influence. It is most damaging when the facts are insufficient in number. Errors in reading time on a stop-watch are cases in point. Especially in timing elements whose cycle in short, the reading may be a few hundredths over or under the absolute time. However, it is just as apt to be one as the other, and in making a number of studies these errors will balance one another so that the selected time will be reasonably accurate.

Cumulative error is a type which does the real damage. It is typified by the inaccurate stop-watch or the short measure. Every time these measures are used, the error tends to cumulate. This class of error must be discovered and the probable amount must be estimated so that proper deductions or allowances can be made. Otherwise, reliable conclusions cannot be formed from the figures.

Certain errors should always be thrown out, as, for example, zero times or answers showing wide variation from normal. At the same time, these widely divergent answers should be carefully studied, as they often lead to important discoveries.

Round numbers many times, because of the ease with which their import is grasped, serve better for comparative purposes, even when more exact figures could be used. The decision as to whether round numbers or exact numbers should be used depends upon the problem. No one expects or would permit a bookkeeper to use round numbers in his accounts, but in order to visualize output figures, gross business, or large bodies of facts, round numbers are close enough. After all, in 99 out of 100 cases in ordinary business statistics, it is relative and not absolute accuracy that is demanded.

Great care must be taken, however, not to mix round numbers and precise figures. Yet it is not at all uncommon for even an industrial engineer's report to include statements such as "a saving of $3,172.50 can be made yearly through installation of the improved method." If

this is merely the sum of a number of estimates rather hastily arrived at, no harm is done in spite of the absurdity of the statement. If, on the other hand, this figure is the result of a careful investigation involving hundreds of items and determined down to the last fraction of a cent, it is misplaced energy, and hence wasted money. Bear in mind at all times that a chain is no stronger than its weakest link, and, hence, a total can have no greater accuracy than its most inaccurate element.

In the case of "Yes" and "No" answers, the probability of error is not so great as in numerical answers. In the former, the line of demarcation is distinct. In the latter, there is opportunity for an estimate rather than actual facts.

For instance, the question "Do you regularly shave with a safety razor?" will bring an accurate answer in most cases—either "Yes" or "No." However, the question "How many shaves do you get out of a safety razor blade?" invites an estimate, because few men know exactly how many times they have used a blade. And the real value of this estimate depends upon conditions of beard, stropping, and so forth, which are not in any case uniform.

5. IS THE COLLECTION OF FACTS SUFFICIENTLY COMPREHENSIVE?

No hard and fast line can be laid down as to how comprehensive a collection of facts shall be made. This is controlled by factors of time, expense and importance of the problem, and so forth. However, the collection of facts must be sufficiently extensive to cover the subject adequately. It is better to err on the side of getting too many facts, than to attempt to form conclusions from too few. Hasty generalizations, fallacies, and other errors in reasoning, largely result from the formation of judgments from insufficient facts. Half-way collection of facts is almost worse than none at all.

A fine illustration of this is described by E. S. Bradford:[1]

A manufacturer of fiber soles suffered an alarming falling off in sales. The product had been improved to a point where it had appeared to be giving general satisfaction, when a marked slump took place. What was the cause? The president sent for his research man and put the question to him. It took almost 30 days of the most active investigation to find the answer. The facts which first came to light were that the color of certain brands was not right; also that some manufacturers had not been sewing on the fiber soles properly. It was found, too, that many shoe repair men did not know how to adjust their sewing machinery when attaching the new sole to the shoe; further, that the shoe repair men who sewed soles on by hand were using leather exclusively.

But the decline in the sale of the fiber soles had been so great that a further search was made and a more fundamental cause was disclosed. There had been an unprecedented falling off in the demand for men's shoes throughout the country, due to the drafting and sending across to the trenches of France of the first million men. These were young men, good spenders, men who bought shoes frequently. Moreover, the war economy wave had spread over the country, and those who were left to "keep the home fires burning" took their old shoes to the cobbler to be resoled, instead of buying a new pair. There had occurred not only a huge falling off in the demand for men's shoes, but a wholesale shifting of what market there remained from new to repaired shoes.

The remedy, so far as there was a remedy, lay in showing the consuming public and the repair men the advantage of fiber over leather soles and in getting the manufacturers and repair men to sew fiber soles on properly. The reason why the men who sewed on soles by hand would not use fiber soles, even when requested by customers, was because the hole made by the awl in the fiber sole closed up before the thread could be put through. So an awl with an eye was recommended, which carried the thread through the sole.

This last point is an example of how a vital fact occasionally raises its head in the most unusual places and calls attention to a condition, the existence of which could scarcely have been anticipated. On this account, the work of the research department should be thorough. The constant presence of factors in a situation which reveal themselves only after much investigation makes

[1]Bradford, E. S., "What to Expect from Business Research," *Administration,* November, 1921.

it, in general, necessary to anticipate some variation from the original outline of every plan, and to allow, always, a certain margin of time and cost. For such factors the research man and the executive must always be on the alert.

Losses of all kinds occur when this rule is violated. In one instance, the development department of a concern manufacturing flavoring extracts, designed a bottle with a patent disburser. This bottle was tested out by hundreds of experiments, by pouring rapidly and slowly, from different positions, and so forth, and seemingly its practicability was fully demonstrated. However, all of these experiments had been made with water, and when the bottle was filled with flavoring extract it was found that it would not pour, due to a chemical action between the disburser and the alcohol contained in the extract.

6. ARE THE FACTS COMPARABLE?

Facts, in order to be compared, must be homogeneous in character; that is, having certain characteristics in common. They must be expressed in terms of the same suit of measurement. One cannot compare pounds and feet, nor can one get a clear conception of facts which are so indefinite in character as to be unmeasurable. And, even though they may be expressed in the proper units, they may be classified incorrectly, and if this error is not discovered, erroneous conclusions again will result.

One of the first decisions which we have found that the investigator must make is to determine the unit of measurement in which he will express the facts that he intends to gather. What he must do now is to make sure that the meaning, originally given to the unit, has not been changed in the course of investigation; that this unit has been applied always in the same way throughout the collection of facts; and that it has always been properly used. Sometimes the whole success or failure of the investigation may hinge on the care which has been taken in the selection and

use of the units of measurement in which the data are expressed.

Very frequently the data will be found, upon examination, to be expressed in several types of units. For instance, the capacity of a plant may be given as so many items of product, or so many machine hours. Other important data may be expressed in monetary units, which in order to be related to other facts must be translated into different terms. Data may be furnished showing a number of employees on the pay-roll, which before it can be used must be analyzed in order to find out what the unit includes: whether it includes or excludes absentees, those sick or on vacation, how long his name is kept on the payroll in case of absence, and so forth.

For example, in one shop the engineer investigating conditions found it hard to get a true perspective of production because the reports furnished by the various departments did not speak the same language. One report was in terms of tons of material handled; another, the number of rivets driven per gang, and so forth. But there was no common unit of measurement which would enable the progress of the work as a whole to be visualized.

It was only when a single common denominator was established—in this case product hours, in terms of which all figures were expressed—that it became possible to discover the "necks of the bottle" in production and to take the necessary action to remove them.

Unsound conclusions or impracticable plans frequently result from basing decisions on facts which are not truly comparable. It is impossible, in market investigations, to compare communities differing in buying power, racial character of population, climatic conditions, and so forth. In an industrial investigation, it is of no use to make time studies when conditions of equipment, layout, and work are different. It is only when these have been standardized that comparable data can be secured which will lead to improvements.

OTHER TESTS

The foregoing are the common tests which are desirable to apply to the facts in any investigation in order to determine their value. These, however, by no means exhaust the tests which may be advisable to apply to any particular problem. In such cases, however, the additional tests which may be necessary in order to bring out the applicability of the facts will in most cases be largely apparent from the nature of the problem itself. In other cases, in applying those which have been suggested, other desirable tests will suggest themselves.

The question comes up as to how extensive this testing shall be. The answer depends entirely upon the problem. If crude comparisons only are desired, imperfect facts will suffice. General information, showing volume of exports and imports, bank clearings, amount of construction, and so forth, will be sufficient for a decision as to trade conditions in general. Very much more specific information, however, tested for pertinency to the individual problem, will be required by the executive planning for the expansion of his business.

Horace Secrist[1] mentions a number of important standards which must be considered in the interpretation of statistics, and in concluding this discussion of "Testing and Interpretation," it will be well to quote the nine standards which he mentions:

1. The truth is the end sought: error is not to be disguised, falsehood tolerated, nor preconceptions favored.

2. Comparisons can be made only between things, conditions, times, and places having common qualities.

3. In interpretation, facts must always be referred to conditions which can produce them.

4. Interpretation should extend to an explanation of the past and a forecast of the future.

5. Distinction should be made between long- and short-time

[1]Secrist, Horace, "Statistical Standards in Business Research," *Journal of the American Statistical Association,* March, 1920, pp. 55-57.

conditions and consequences; between transitory skirmishes and general tendencies.

6. Distinction should be made between the result of a single cause and a combination of causes.

7. Distinction should be made between drawing a particular deduction and giving it general application.

8. Similarities and differences should be appraised in the light of particular application. Similarities which are seemingly complete and differences which are fundamental for one purpose may be ignored for others.

9. The detail of interpretation should conform to the nature of the problem and the capacity of those interested. Not infrequently an exaggerated accuracy, which the nature of the basic data does not justify, nor the occasion for summarizing warrant, is worked out in detail by means of percentages, averages, and other summary expressions. Similarly, far-reaching conclusions are sometimes drawn from inadequate data by elaborate and over-refined methods. Statistical analysis then appears as an inverted and unstable pyramid.

Likewise, involved and complex interpretations are sometimes prepared for those who are statistically ignorant of refined processes or for those who are disinclined to follow or uninterested in pursuing an elaborate analysis. A statistical interpretation designed to influence executive actions or to enlist administrative support is rarely, if ever, to be couched in the same language or to include the same detail, as one which is intended to serve the simple purpose of record. Consumers of statistics not only differ in their statistical interest but also in their statistical horizons.

SUMMARY

In concluding this chapter on testing the facts, there is probably no better summary of the subject than has been given by Professor Bowley, in a summarization which he made of the characteristics of good statistics. This is as follows: "The unit of measurement should be absolutely defined, its attributes should be precisely those which are related to the inquiry, and the group should be sufficiently homogeneous for the purpose for which the measurement is needed. The collection should be actually universal or based on samples, scientifically chosen, with adequate tests

of their sufficiency. A sufficient number of observations should be made to test stability. Only statistics collected and computed by the same methods and on the same definitions can be compared. When two unlike totals are brought into relation with each other, the causal connection between the units of the one and the units of the other should be close and inevitable. The accuracy of the measurement, as limited by the definition of the unit, should be calculable."

XIV

TABULATION AND PRESENTATION

Tabulation defined. Purpose of tabulation. Advantages of tabulation. Technique of tabulation: (1) preparation of data; (2) designing a table; (3) rules for tabulation; (4) common errors. Averages: (1) arithmetic mean; (2) weighted average; (3) median; (4) mode. Effective use of averages.

In many investigations it is possible to pass directly from the classification, testing, and interpretation of the facts to the formation of the conclusions. This is especially true when only a few simple facts are involved. When, however, the facts are numerous, dissimilar in character, or expressed in numerical or categorical terms, an intervening step is necessary.

The purpose of this step is to summarize the data from a quantitative standpoint and express it in such a way that the mind can readily evaluate it both qualitatively and quantitatively. The principal forms which this summarization assumes are the following:

1. *Tabulation,* the purpose of which is to reduce masses of data to a logical order according to the units of measurement in which data are expressed;
2. *Averages,* the purpose of which is to secure a single expression to represent large aggregates of numerical data having common characteristics but differing slightly in quantitative value.

Tabulation and averages are very closely interrelated, but each has a distinct field. Of the two, tabulation is probably the most widely used, inasmuch as facts of all kinds can be tabulated if it is possible to reduce them to sufficiently brief compass that they will fit in a table. On the other hand, averages can be used only in connection with numerical data, which restricts their use considerably.

In order that the advantages and limitations of these may be thoroughly understood, each will be taken up now for brief consideration, so as to bring out clearly to what type of work each is best adapted and how it may be used most effectively.

TABULATION DEFINED

Tabulation means to express in the form of tables. Tables are surfaces, whose length and breadth are not disproportionate. Being surfaces, they can be read in either one of two directions:

1. From the "stub," which shows the basis of the horizontal classification; or,
2. From the "caption," which shows the basis of the vertical classification.

The value of a table is probably the most clearly brought out by comparing two common methods of presenting facts —the printed page and the railway time-table. In the page you are now reading you will note that the characters are arranged in lines running from left to right and that they can only be read in that way. In the time-table it is not only possible to read from left to right, but also up or down. In some tables it is often possible to read diagonally.

Data expressed in numerical terms lend themselves most advantageously to presentation in the form of tables. Other data, however, which can be compressed into brief statements, may also be tabulated to advantage when there is any gain secured from reading them in more than one way or when it is possible to grasp the data more quickly in that form. For example, see the tabulation of answers to a questionnaire on motor trucks which is shown in Figure 5, page 166.

THE PURPOSE OF TABULATION

The purpose of tabulation is to reduce masses of data to logical order, based on the units of measurement in which

the facts are expressed. Tabulation must not be confused with classification, which, it will be recalled, had for its purpose also the reducing of facts to order in accordance with their essential characteristics. In the one case, the basis is quantitative, and in the other, qualitative.

Based upon this conception of the function of tabulation, it will be readily seen that its use will tend to produce the following benefits:

1. Definite bases are furnished for the comparison of related facts;
2. Trends are clearly shown;
3. Relation of cause and effect is clearly revealed;
4. Underlying principles are laid bare;
5. Profitable plans of action are indicated.

While not actually forming judgments, inferences, or conclusions regarding the facts, tabulation has for its purpose the arrangement of the facts, so that such conclusions can be readily drawn. It is the "tying-in" step between analysis and the formation of conclusions.

To handle tabulation effectively demands a working knowledge of statistics and statistical methods so that one can:

1. Select the best units to use in tabulating the facts;
2. Devise the most satisfactory methods of arranging the facts;
3. Determine the most satisfactory method of interpreting the facts;
4. Present the result of the interpretation in the clearest possible form.

Statistical methods play such an essential part in the preparation of the data that a brief discussion of methods is advisable. However, such discussion as is possible in these few pages can only hit the high spots and cover the type of statistical work which will be sufficient in the majority of investigations. There are many valuable books published on statistical methods, and it is recommended that whenever the use of statistical methods is essential, a careful study should be made of these authorities in order that the right methods may be selected.

ADVANTAGES OF TABULATION

It is quite possible to achieve the foregoing benefits without tabulation. In fact, it must be so accomplished when the facts are of such a nature that they do not lend themselves to arrangement in the form of tables. However, in all cases where the facts can be summarized in that form, tabulation has many advantages, the most important of which are the following:

1. It simplifies the summation of the facts. While it is quite possible to secure the necessary totals without tabular arrangement, this is only accomplished with considerable difficulty, and the components of the totals are not visualized.
2. It visualizes the order and importance of the facts. Tabulation emphasizes the considerations which establish the order and makes possible a rapid survey of the whole body of facts.
3. It simplifies the comparison of the facts. Through placing relative facts in juxtaposition, comparisons are made obvious and further analysis encouraged.
4. It economizes space. Usually data of any involved character take less space to present in tabular than in descriptive form.
5. It makes for ease of utilization. Tables are much easier to read and understand than descriptive matter, no matter how carefully the latter is prepared.

In classifying data for tabulation, the chief concern must be to arrange the material in such a way that their full significance becomes apparent.

THE TECHNIQUE OF TABULATION

In preparing tables which will effectively present the facts, the investigator must deal more or less with statistical methods. While in most cases there is no need for the elaborate use of statistics, yet whenever the facts are of such a nature that they can be presented numerically, there is no doubt that the results are more convincing. The vis-

ual picture furnished from properly prepared tables is clearer than the most elaborate description.

In all cases the order and arrangement is determined by factors inherent in the problem. The arrangement must always be considered as a function of the purpose and should vary with any change in purpose. Before attempting to put data in tabular form, first subject them to careful examination in order to determine the relationship of the different parts.

In taking up the study of tabulation as an aid in summarizing the facts so that effective judgments can be formed from their consideration, it will be helpful to divide the subject into the following divisions:

1. Preparation of the data
2. Designing the table
3. Rules for tabulation
4. Common errors in tabulation

1. *Preparation of Data.* When there are not a great many facts to be tabulated, it is frequently possible to make the tabulation direct from the recapitulation sheet or the form on which the facts were assembled. For instance, in the example given in Figure 6, a table showing the summary of the data expressed on that recapitulation sheet could easily be prepared directly from the information contained on it. This is true because the number of questionnaires involved and, consequently, the amount of information to be tabulated was relatively small.

In investigations, however, where a considerable amount of information is gathered, it is often a physical impossibility to tabulate directly from the recapitulation sheet, and other means must be used. Ordinarily, in such cases the means utilized are tabulation cards. On these cards the data are classified and entries are made showing the information received. One card is made out for each questionnaire, interview, or source from which the facts are received. After the facts are gathered, tabulation consists in sorting out the data according to the different classes and adding

up the different results which have been secured. These results are then listed and form the basis from which the table is prepared, showing the distribution of the answers.

In the usual type of investigation, the sorting and listing of the data can easily be done by hand. In extensive collection of data, it is advisable to use mechanical methods in the form of a tabulating machine. With these machines, special tabulating cards are used with columns and space provided for the different classifications to be recorded. Previously the data must be codified in such a way that they can be expressed on these cards. At the proper intersection of a horizontal or vertical column, a punch mark is made in the proper space to show the type of answer. These cards are then placed in the tabulating machine and the sorting is accomplished by an electrical contact through the holes in the cards. This sorting may be continued as closely as desirable.

An example of such a tabulating card is shown in Figure 7, this being one of the cards used by the United States Bureau of Census in tabulating the data collected by the Census enumerators. Inasmuch as mechanical methods of tabulation are only required in very extensive collections of data, no further discussion is given here but the treatment will be confined to tabulation as it is ordinarily called for.

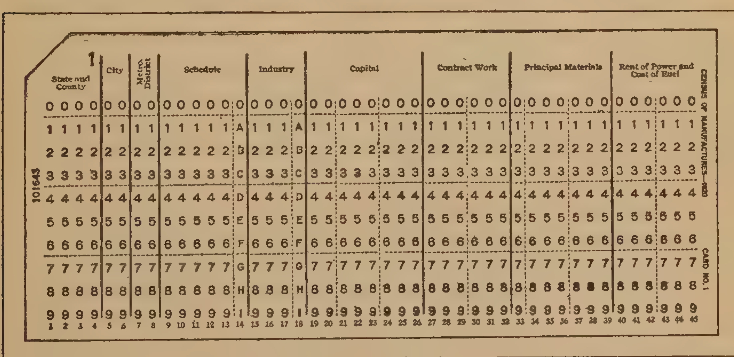

Figure 7: One of the nine different tabulating machine cards used by the Census Bureau in compiling the *Census of Manufactures.*

If the investigator is interested in learning more regarding the special application of mechanical tabulating devices, he is referred to Chapter XV of *Graphic Methods of Presenting Facts,* by Willard C. Brinton, and also to the advertising literature and descriptive data furnished by the Powers, Hollerith, and National Cash Register Companies.

Assuming, then, that the sorting and tabulating will be a hand proposition, the procedure involved consists in checking over the cards and of counting the frequency of each item. For ordinary purposes, a tally sheet is entirely practical, on which a check-mark is made for each item as it is noted in checking over the cards. Where larger quantities are involved, it is often advisable to use a listing machine. Owing to the great possibility of error in either, these listings should be checked over as closely as possible, otherwise errors in the total will be carried forward to the next step.

2. *Designing the Table.* There are two things involved in the design of the table on which the summary of the data is to be recorded. The first of these is concerned with its form; that is, the subdivision of the detail which it is desirable to show. The other is from the standpoint of the content matter or the controlling factors which govern the information.

Taking up for consideration, first, the design of the table from the standpoint of form, tables are usually classified as:

(*a*) Single tables, showing one classification of the facts, as, for example, total volume of output by years;

(*b*) Double tables, showing two classifications of the facts, as for example, total volume of output by years and classes of products;

(*c*) Triple tables, showing three classifications of the facts, as, for example, total volume of output by years, classes of products, and plants.

Other still more complicated forms are used in specific cases where a more extended classification is desired. However, very little is ordinarily gained through increasing the

complexity of a table and when more than three classifications of the material are desired it is ordinarily better to make additional tables of simpler form than to try and get all of the matter on one complex table.

From the standpoint of the controlling factors or the content matter, a satisfactory classification of tables is as follows:

(*a*) On the basis of time;
(*b*) On the basis of correlation;
(*c*) On the basis of the variation of the elements.

The first class of tables is adapted to data in which the controlling factor is time. It is typified by the ordinary time-study record, where the data, regardless of their nature, are controlled by this consideration.

In the second class of tables are included those where comparison is desired of certain relative matters at a particular time; time here is only incidental, the main consideration being the relation of the elements. The table will tabulate the data according to one classification, horizontally and another vertically. The summarized data secured after sorting and counting the details are then entered at the intersection point between two classifications. The ordinary output record is a good example of this type of table.

The third type is commonly known as the frequency table. In it the data are arranged according to the variations of the elements composing them. Ordinarily these elements are grouped in an ascending order and the frequencies are posted directly opposite the basic classification.

In making use of frequency tables, it is especially important that the width of the group be identical, otherwise it is impossible to form comparisons from the data which are given.

3. *Rules for Tabulation.* Tabulation is distinctly the tool of the statistician. It is only incidentally used by the

engineer or investigator in order to prepare certain portions of his data. As a consequence, the statistician has made the widest study of tabulation and, as a result of these studies, certain useful rules for tabulation have been developed which it will be well for the investigator thoroughly to understand.

One of the most practical outlines of rules for tabulation is that developed by Horace Secrist.[1] These rules are based upon a wide experience covering many years and should be thoroughly mastered by every one attempting this type of work.

Tabulation is a means, first, of recording in fixed form a classification previously developed, or second, of placing similar facts into juxtaposition or into groups as a preliminary to a final classification. It is a device for projecting on a surface, capable of being read in two dimensions, a classification which has been worked, or is being worked, out. It is a method of recording a process of thought. It is inelastic in structure; the facts which it contains are in truth "locked up." Classification precedes, tabulation follows. The sequence of thought is from purpose to method.

The statistical standards to which tabulation must conform are as follows. It is necessary to say that it is not my intention so much to formulate a set of rules governing the make-up of tabulation forms as it is to develop statistical standards in tabulation of permanent value, the realization of which may require a variable technique:

1. Every tabulation surface should faithfully record the classification which it is intended to depict. The purpose of tabulation and the standard to which it must conform cannot be divorced.

2. There is always a best form of tabulation for a given purpose, as there is a most logical basis of classification. Indiscriminate choice of forms is as much without justification as is a meaningless or superficial classification.

3. Every tabulation should be adjusted in form and complexity (*a*) to the subject-matter which is to be expressed, and (*b*) to the person for whom it is prepared or the end to which it is addressed.

4. The order of detail in tabulation forms should be adjusted

[1]Secrist, Horace, *Statistical Standards in Business Research,* The American Statistical Association, pp. 53-54.

so as to be emphatic. It should be natural, not artificial; convincing, not purposeless.

5. Statistical tables should carry only relevant data. The reciprocal relation between relevancy of fact and the purpose to be accomplished by tabulation is the thought which is stressed.

6. Statistical tables should carry on their faces both their justification and their explanation.

7. The details of statistical tables should be mechanically accurate and their grouping and arrangement consistent, logical, and serviceable.

8. The natural order in classification is from detail to summary; the serviceable order in tabulation is from summary to detail.

9. Brevity is said to be "the soul of wit." It is equally true that conciseness in tabulation is the secret of its effectiveness for most practical purposes."

To which may be added a tenth—When comparisons are to be made between tables or divisions of tables, they should, as a general rule, cover equal ranges.

4. *Common Errors in Tabulation.* Needless to say, data cannot be tabulated effectively unless the preliminary work of planning the investigation, collecting, classifying, and testing the facts, has been carefully done. But even when these steps have been carefully handled, the investigator, unskilled in tabulation but realizing its advantages, often makes mistakes in preparing the tables. As a result, he is often misled as to the sufficiency of the information and led to form unsound conclusions.

Some of the most important mistakes in tabulation which must be avoided are the following:

(*a*) The attempt to summarize facts without a definite understanding of the units of measurement in which they are expressed;

(*b*) The failure to note whether the facts are properly comparable;

(*c*) The tendency to disregard detail, to make improper use of averages, and to place too great emphasis on totals;

(*d*) Lack of knowledge of the technique of preparing tables.

Tabulation, as it has been stated before, is primarily concerned with the summarizing of numerical data. Hence,

it is essential that the investigator be sure as to the units of measurement in which the data are expressed. A table showing the exports and imports of Great Britain, France, Germany, Italy, and the United States expressed in terms of the monetary units of those countries would have no real value until the data had been edited and expressed in terms of the same unit of measurement—the dollar, for example.

Even when expressed in the same unit of measurement, the facts tabulated may not be truly comparable. In making use of data compiled from state, governmental, or private reports, great care must be taken in making certain that the data will be comparable not only as to the year which is covered, but also as to the content of the items included under the heading.

For example, in the *United States Census of Manufactures,* there is frequent duplication in the figures given for the total value of products for the various industries. This duplication arises from the fact that the total for an industry may include figures from plants which manufacture products in various stages of completion, such as castings, forgings, and so forth, as well as plants manufacturing only fully finished products such as automobiles, washing machines, and so forth. In many industries these intermediate products are produced in their own foundries or shops, and when this is the case, they are not separately reported. Therefore, the total figures are not truly comparable for various industries or even for the same industry over a period of years, unless the extent of integration is accurately known.

Summaries, just the same as averages, are "short cuts," and in that very fact lies one of the greatest dangers surrounding their use. It is so easy to apply a certain average fatigue allowance, that the investigator will oftentimes not analyze the nature of the fatigue in a specific case in order to determine its true extent.

Not only that, but there seems to be a certain fascination in summaries, especially when they are neatly type-

written or printed. They suggest finality and only too frequently insufficient analysis is made of the detail from which they had been prepared in order to see if they are accurate or not. Only by maintaining a consistent attitude of questioning every fact can this error be avoided.

Dr. John Venn, has admirably summed up this danger in his comments on the use of averages, and what he says of averages is just as true to totals or summaries of any kind. He says, "Every sort of average—and there are many such sorts—is a single fictitious substitute of our own for the plurality of actual values existent in the results which are naturally or artificially set before us. It is impossible, therefore, for the former in any case effectually to take the place of the latter. But the extent to which it may succeed or fail in doing so will depend upon the value of the facts presented to us and still more upon the precise object we have in view."

In all the foregoing instances, the errors arising from improper tabulation can be corrected by applying the suggestions given in previous sections of this procedure. Those arising from a lack of knowledge of the technique of tabulation are in a different category, however, and call for a thorough mastery of the rules and suggestions given in this chapter.

AVERAGES

Frequently during the collection of the facts, the investigator finds himself in possession of large aggregates of numerical data having common characteristics, but differing slightly in quantitative value. The mass of detail precludes the possibility of separately considering each individual item, and the only practical way to deal with the data is to prepare summaries which, while not presenting all the information which may be secured from the original data, do bring out the fundamental tendencies which underlie them and which casual inspection does not ordinarily indicate.

These summaries are called averages and when properly used are very valuable tools in the hands of the investigator. The term averages is quite familiar to everyone. But as used by the investigator it has a somewhat different meaning from that which is given to it in the ordinary walks of life. Rogers Hornsby's batting average for 1925 was 403, but properly speaking this was not an average at all, but rather a percentage.

Also, in ordinary speech, we refer to the average man, the average turnover, the average price for a commodity, and so forth, but as a rule these "averages" have not been determined by any exact method. They are rather estimates or guesses based on the individual conception of what the normal or average should be in each case, and are just as accurate as the individuals making them are qualified to make such an estimate.

The same is largely true of the averages upon which business executives base many of their decisions, policies, and plans. With increased emphasis on exact methods of accounting has come a greater accuracy in preparing these averages, but even today a very large number are merely shrewd guesses. Through a better understanding of the proper use of averages and the right way to compute them, greater accuracy can be incorporated and even greater benefit secured from their use.

From the foregoing examples of familiar uses of the term "average" it is apparent that the main distinction between the ordinary conception of the term and that of the investigator or scientist is based on the way in which the averages are determined. Instead of being estimates or guesses, they are mathematically or definitely computed. Instead of being broad generalizations, they are accurate indexes to the facts for which they stand. Instead of being largely of one type, they are of many types, each being best for a particular purpose.

The last statement should receive especial emphasis. There is no one best type of average which can be applied

to any and all kinds of facts. The investigator, therefore, must know what are the different kinds of "averages," how to compute them correctly, and when they can be used most advantageously. In investigational work, the following types of averages can be used to advantage:

1. The "arithmetic mean," which is derived by dividing the sum of a series of numbers by the number of instances;
2. The "weighted average," which is derived by multiplying each term in a series by its weight or value and dividing by the sum of weights;
3. The "median," which may be defined as the middle term in a series which has been arranged consecutively;
4. The "mode," which may be defined as the common or characteristic term in a series.

The exact nature of this average, the proper mode of computation, the type of facts to which they are best adapted and how to use them most effectively will be better understood after each has been carefully described.

1. *The Arithmetic Mean.* The arithmetic mean is undoubtedly the type of average which is in most frequent use in the field of business. It is derived by dividing the sum of a series of numbers by the number of instances. For example, the arithmetic mean of the series 5—10—12 is:

$$\frac{5 + 10 + 12}{3} = 9$$

The advantages of the arithmetic mean come largely as a result of the fact that it is so easy to compute. Only a minimum knowledge of mathematics is required, so that almost any one can use this type of average. Because of its ease of computation as well as because of the fact that it has been used for many years, this method of averaging is well known and, therefore, requires little or no explanation on the part of the investigator in showing how he has derived his figures.

To offset these advantages the arithmetic mean has cer-

tain weaknesses which limit its field of usefulness to a considerable degree. The most important of these are:

(*a*) All of the terms in the series must be known in order that it may be computed.

(*b*) The resulting average may be wholly fictitious as is the case of the result "9" in the series given above. This, however, may not really mean anything, the purpose being to secure a representative summary without its being necessary that this expression should have an exact counterpart.

(*c*) The average tells nothing at all regarding the make-up of the series. It ignores the detail, lumping things together and reducing them by an arbitrary mathematical process to a common denominator. For instance, the arithmetic mean of a series 4—7—10 and 15 is also 9 and the same is the case in the series 2—4—11—13 and 15.

(*d*) No allowance is made for differences in the significance of the items making up the series. For example, in computing the average number of employees, output, or information of this character regarding the factories in a certain district, if most of the factories are small but there are one or two very large establishments, the arithmetic mean would give an entirely wrong conception of the facts and lead to absolutely erroneous conclusions.

(*e*) The use of the arithmetic mean is confined exclusively to numerical series and it, therefore, cannot be used in averaging or interpreting a series of statements or observations which are not of a numerical character.

If, therefore, the series is incomplete or if it is necessary that the average be represented in the series or if the series contains widely fluctuating terms, the arithmetic mean should not be employed. In most other cases, it gives a very practical result when used with discrimination. In fact, it may be emphasized that at no time should mathematical computation be relied upon entirely in determining an average. Judgment and discrimination are prime essentials to effective analysis, and mathematics is only an aid designed to lighten the burden of handling the detail.

2. *The Weighted Average.* The weighted average is designed to be used in those cases where the arithmetic mean

does not furnish a true average because of the different degrees of significance attached to the members of a series. It is computed by multiplying each term by its weight or value and dividing the total by the total weight or value.

A good example of the use of the weighted average may be taken from the accounting of factory stores. In this work the question frequently comes up as to the average price of materials which should be filled in on cost tickets in cases where several lots are in stock which have been secured at different prices. For example, supposing there are in stock 700 pounds of material procured at 7 cents per pound; 500 pounds for which 8 cents per pound was paid; and 100 pounds for which 12 cents per pound was paid. According to the arithmetic mean, the average price of this material would be 9 cents per pound, but if figured according to the weighted average method, it would be as follows:

700 pounds at .07 cents per pound	= $ 49
500 pounds at .08 cents per pound	= $ 40
100 pounds at .12 cents per pound	= $ 12
1,300 pounds........................	$101

Weighted average equals 7 10/13 cents per pound

From the above illustration it will be readily seen that variations in the quantity or value of the different items comprising a numerical series will modify to a considerable extent the average, and when these significances are at all important, the weighted average method should be used in preference to the arithmetic mean. Otherwise, however, the weighted average is a refinement of the arithmetic mean and is therefore subject to the same disadvantages which we have already mentioned as applying to it.

3. *The Median.* The median may be simply described as the middle term in a series which has been arranged in consecutive order. When the number of terms in a series is odd, then a median falls at the middle point. When, however, the series is even, it is fictitious in character inasmuch as it will fall midway between the two middle terms.

For instance, in computing the average size of the factories in the district mentioned in the former illustration, the median would be located among the small factories and, therefore, it would be more typical of the average than the arithmetic mean. To show the method of determining the median, let us take for example the series 2—3—5—6—8—12 and 20. The number of terms in this series is 7, and, therefore, the median will fall on the fourth term, which is 6. The arithmetic mean of this same series is 8, and, therefore, it will be seen from casual inspection that the median is, in this case, a more typical term and for many purposes a closer average than would be the arithmetic mean.

Properly speaking, however, the median is not an average but is rather the expression of the division point in a series. It is easy to determine and in most cases is as fully characteristic of any group as the arithmetic mean. Another advantage is that it can be computed when the size of the extremes is unknown, indefinite, or impossible of measurement, provided the number of terms and the frequencies are given. This is especially useful when some of the measurements in the series are inaccurate or indefinite.

The median has another advantage in that it can be used to secure an average of a series which is composed of terms which are not numerical in character. For example, the replies to a questionnaire may give the following answers in reply to certain questions: good, bad, poor, excellent, medium, fair, and so forth. If these answers were sorted and arranged in an ascending or descending order, the middle terms will be characteristic and will make possible the tabulation of these replies which otherwise could not be done.

The median, however, has certain disadvantages which limit the extent to which it could be used. These are as follows:

(*a*) The significance of the items of either extreme is ignored.

For instance, in the series given, as an example, the median would be 6, even though the series were changed so that the last three items were very much larger than those given. As, for example, in the series 2—3—5—6—80—120—1500.

(*b*) In cases where the average must represent an actual term in the series, the median sometimes cannot be used, inasmuch as in an even series the median at times will fall at a point midway between two numbers in the series and thus be fictitious in character. For instance, the median in the series 2—4—6—8 is 5, a term which does not occur at all in the series.

In numeric series, therefore, where the number of terms and frequencies are known but the actual size of extreme terms is indefinite, the median furnishes a serviceable average, as is also the case in non-numerical series. In such cases the median is recommended as a quick method of securing an average.

4. *The Mode.* The mode in any series is the most characteristic term. It is the typical term and, being typical, is truly representative. It is real and always expressed in the series. In determining the mode it is the number of instances which control its selection and not the size or value of the items. For example, the Bureau of Business Research of Harvard University, in the investigation of the expenses of operating retail grocery stores, used the mode for the purpose of averaging the data collected. This is borne out by the following quotation from *Bulletin Number 5:* "The bulk of the figures are between 4% and 8%, concentrated around 6.5%. A sufficient number of stores spent only 5% of their net sales for salaries and wages of sales force to indicate that that figure is ordinarily possible of attainment."

Although business executives are not usually familiar with the term mode, it is this type of average which lies at the base of many of the averages which are used in ordinary life. For example, when he speaks of the average worker, the normal rate of interest, the average turnover,

and so forth, he is thinking of the typical worker, the most common rate of interest or turnover.

Of course these averages have not generally been determined scientifically and are not, therefore, properly modal. They are, however, of the same type, and consequently there is a broad field for the use of this average in all fields of endeavor.

As compared with the arithmetic mean and the median, the mode possesses the following advantages:

(*a*) Only a part of the data is required for its determination;
(*b*) The mode is always represented in a series;
(*c*) The mode can be used to determine averages of any series whether the terms are numerical or statements of fact.

In using the mode, however, care must be taken to see that the items are sufficient in number so that there is an unmistakable point of concentration. If there are a number of items occurring with equal or nearly equal frequency, the mode is often indeterminate. In the mode, as in the median, extreme items are ignored and, hence, when these have a significance, the arithmetic mean or weighted average must be used.

The arithmetic mean, weighted average, median, and mode include those averages which can be used to advantage in ordinary investigational work. There are other types of averages such as the geometric mean, harmonic mean, index numbers, and so forth, which are used for special purposes, but as a rule they are not used to a sufficient extent in investigational work to warrant any more than the mention of them at this time. In fact, if any extensive statistical work is necessary, the investigator should have a special training in higher mathematics combined with the study of standard text-books on statistical methods.

THE EFFECTIVE USE OF AVERAGES

Before concluding the subject of averages, a few general comments on their use in business will be helpful to the

investigator. In the first place, it may be repeated for the sake of emphasis, *that no average is good for all purposes*. The frequency, arrangement, and size of the items in any series affects each type of average in a different way. Selection, in all cases, should be based on the purposes in mind combined with a careful inspection of the facts in order to ascertain their real significance. The most common average used in business is the arithmetic mean, but there is no reason why the median and the mode should not be used more, provided that discretion is used in applying them.

The use of averages in order to condense masses of detail into more compact form is based on the mathematic law of probability. This is often called the "law of averages," which may be stated as follows: "A reasonably large number of items chosen at random from among a very large group are almost sure on the average to reveal the characteristics of the group as a whole." A surprisingly large number of the decisions in both ordinary life and business activities are based upon the "law of averages." For example, the mortality tables which practically form the basis on which the insurance business is built are outstanding illustrations of the practical accuracy of this law.

In fact, the investigational process itself is to a very considerable extent based upon the "law of averages," inasmuch as it is physically impossible for the investigator to gather in most cases even a large part of the information which it is possible to obtain about any subject. He must, as a rule, be content to select a representative number of instances for observation and consideration and base his conclusions on these data.

Averages, in character, are very similar to generalization. In determining them, details must be ignored, because it is the essential purpose of averages to avoid details. But the application of averages begins the process of interpreting the facts, which continues throughout the remaining subdivisions of this division of the investigational proce-

dure and is finished only when final conclusions have been drawn.

The use of such generalized expressions necessarily establishes certain limitations as to usefulness. Sometimes their employment indicates neglect or willingness to make a more searching inquiry. They must be used with judgment and caution; but, on the other hand, when detail can be neglected, averages often give an accurate picture of tendencies. The use of judgment and discrimination in the use of averages cannot be too greatly emphasized. To depend entirely on mechanical computation in determining an average is to invite disaster. Unaided by the judgment, essential details are apt to be overlooked and erroneous conclusions formed.

XV

SUGGESTION AND INFERENCE

Purpose of suggestion and inference. How inferences develop. Constructive imagination; knowledge and experience. Forming inferences. Systematic trying of new combinations. Generalization. Analogy. Helpful rules for developing ideas: (*a*) make a definite start; (*b*) question everything—analyze; (*c*) write down the ideas as they occur; (*d*) talk the problem over with some one; (*e*) relax occasionally; (*f*) stick everlastingly to it. Testing inferences.

THE function of this step in the investigation procedure is to discover the solution to the problem. This may be the explanation for the facts or it may be the suggestion of a new way of handling the work. If no new facts were encountered, or if the judgments grouped themselves along familiar lines, this step would not be necessary and we could pass immediately to the formation of conclusions.

However, experience rarely repeats itself exactly; consequently, in almost every case, it is necessary to cast about and find an explanation or solution that will conform to the facts observed. This procedure is known by the name of inference and consists of a process or series of processes of suggestion and association.

Before it is possible to think about an observation, its characteristics must be noted, and the only way of doing this is by defining and relating the observation in question to some broad principle established as the result of past experience. That is the purpose behind classification, and through this means a number of ideas or facts having the same fundamental basis are grouped together.

These observations, being classified, are then tested in the only way possible at the time—that is, by referring them to previous experience, and in the light of our general body of knowledge, every new experience is interpreted.

That is as far as thinking is usually applied in the preliminary stages of the investigation.

Thinking of this type simply classifies the observations ready for use when needed. There is no progress, however, until the act of thinking gives rise to some new idea which is neither a part of the observation nor of our general knowledge but is, nevertheless, brought out and suggested by consideration of both. The observation in question contributes a part; our general body of knowledge contributes the rest; and the combination of the two produces a new idea. This is the creative feature which characterizes inference.

Inference, in many cases, is very much like solving a cross-word puzzle. One can read through the list of definitions starting with number 1 horizontal and fill in words that he thinks should fit, or he may take a more systematic method. Reading through the definitions he finds one of which he knows the correct word and fills it in. This gives him certain letters and clues to other words. By following this plan consistently, he can work out any puzzle.

So, in the study or analysis of business problems, inferences or suggestions of possible solutions may be unsystematically or systematically developed. Many possible explanations of the facts, solutions to the problem, and so forth, will come to mind without effort. Other suggestions will occur as a result of a systematic trying of new combinations, the memory of past experience, or the result of deliberate reflective reasoning directed along definite lines.

It is not necessary to wait until one has gathered all of the facts in order to begin the formation of inference. Ideas of possible explanations, possible solutions to the problem, are continually suggesting themselves throughout the entire procedure of investigation. In fact, the development of a tentative plan for carrying on the work itself was made possible only because some well-founded ideas as to the probable conclusion had been formed. From these ideas was developed the working hypothesis which guided the

subsequent work, but which was in effect nothing but a suggestion or an inference.

Then, too, in the collection of the facts, one is often guided to new sources of information through suggestions of various kinds. All of this represents legitimate use of inference; and so long as this use is subordinated to the main purposes comprehended in these steps, the use of suggestion is of great value. It is only when one allows the suggestions or ideas as to probable solutions to lead him to form hasty conclusions, before all the facts are gathered, that he is led into error.

HOW INFERENCES DEVELOP

Now that the importance of inference is clear in mind, let us see how they are developed. As it has been shown, inferences are suggestions of possible explanations of the facts, or solutions to the problem. Inferences and suggestions are used here synonymously. In content, inferences range from vague ideas or suggestions to definite theories or hypotheses which offer reasonable explanations or probable solutions.

These suggestions may be developed in a number of ways, but largely they are drawn from:

1. The constructive imagination of the individual;
2. The store of facts, rules, and methods he has carried over from previous experience.

1. *Constructive Imagination.* Like the reporter who must have "a nose for news," so the investigator must have a speculative curiosity about the facts he has observed. He must cultivate a questioning attitude toward the facts, constantly asking: why? what for? what do they mean? and so forth. This questioning attitude, this insatiable curiosity properly directed, and this freshness of view-point, have been outstanding characteristics of the leaders, inventors, and discoverers of all ages.

The distinction between thinking and constructive imagi-

nation is often hard to draw, but there is one. Constructive imagination creates new mental concepts of the facts and observations. Thinking, on the contrary, is concerned rather with the reorganization and reconstruction of the elements of past experience.

Just as inferences represent potential conclusions or solutions, so constructive imagination is largely the capacity which creates inferences, and that is why vision was so strongly emphasized in Chapter III.

The part which the constructive imagination plays in developing new methods and processes, devising better ways of doing work, improving marketing plans, and so forth, is not realized by many business men. With some the function of imagination is associated with fiction rather than with fact. While this is partly true, yet it is still more true that behind the wildest flights of imagination there must be reality. No writer of fiction is able to go beyond his personal knowledge and experience in depicting a character or a situation. Imagination, therefore, must at all times keep in touch with the facts. It represents not what the fancy suggests but what the known facts necessitate.

Professor Tyndall, in *The Scientific Use of the Imagination,* has admirably brought out the value of imagination, and it would be helpful for every one to read this essay. One paragraph in particular states clearly the essence of the matter:

> We are gifted with the power of imagination . . . . and by this power we can lighten the darkness which surrounds the work of the senses. There are tories in science who regard imagination as a faculty to be feared and avoided rather than employed. They had observed its action in weak vessels and were unduly impressed by its disasters. But they might with equal justice point to exploded boilers as an argument against the use of steam. Bounded and conditioned by cooperant reason, imagination becomes the mightiest instrument of the scientific discoverer. Newton's passage from a falling apple to a falling moon was, at the outset, a leap of the imagination . . . . And in much that has been recently said about protoplasm and life, we have the outgoings of the imagination guided and controlled by the known

analogies of science. In fact, without this power our knowledge of nature would be a mere tabulation of coexistences and sequences. We should still believe in the succession of day and night, of summer and winter; but the soul of Force would be dislodged from our universe; causal relations would disappear, and with them that science which is now binding the parts of nature to an organic whole.

The development of useful suggestions and ideas about the facts observed calls for considerable initiative and originality. These capacities grow directly out of the possession of constructive imagination. The observer sees beyond the facts which have been observed. He views them in a new light; discovers new meanings, attributes or qualities; visualizes the connection between these new interpretations of the facts and the purpose or objective of the investigation; and puts the result into action.

Lack of imagination is frequently the reason for failure of wage-payment plans. Operators greatly exceed the standards which have been determined, which encourages rate-cutting and breaks down the value of the work. Even the ablest engineers often go wrong on this account.

For example, a very capable engineer made a study of the transcribing department of one large corporation and set standards for the operators with a bonus calculated so that the best girls would make enough extra earnings weekly to keep production at a high rate.

The standards had been developed with great accuracy after considerable study and so far as the items individually were concerned, they were correct. The engineer had overlooked one fact, however. His standards implied that in the form dictation, the proper paragraphs would be looked up and typed from copy. As a matter of fact, after the rates were set and the girls discovered that they could make good money at the job, they memorized practically all of the forms and paragraphs, thus eliminating sufficient time so that they were enabled to increase their earnings more than 50%.

Of course, the increased output and decreased overhead

per letter made it pay the corporation to maintain the bonus even in face of seemingly excessive earnings. However, the engineer's constructive imagination should have suggested to him that memorizing the paragraphs and forms would be the logical thing to do and he could then have planned his standards accordingly, giving the employees a real target to work toward, as under present conditions it is not at all certain that the volume of production is as high as it might be.

2. *Knowledge and Experience.* The development of inferences is a form of discovery applied not only to finding out more about the facts themselves, but also to taking known facts, forming from them new combinations, and thus creating additional knowledge. This cannot be accomplished by the constructive imagination alone, even though it may be of the very highest type. Any one can make suggestions about how to run a factory efficiently, but those made by persons who do not possess a personal knowledge of the operations performed in a factory would probably be of little value.

In order to develop useful suggestions along with the constructive imagination, therefore, there must be a working knowledge of the subject. A theoretical knowledge is not sufficient. There must be combined with this a practical knowledge, gained through the actual doing of the work in question.

For example, in our engineering schools in times past the students have been given a careful theoretical training in engineering. Valuable as this is for purposes of training the mind, yet before the graduate students could become useful parts of the business machine, it was necessary for them to acquire practical experience.

Through the use of shop laboratories, engineering students today are acquiring more of that practical view-point which has heretofore been lacking. Even now the competitive conditions of business cannot be duplicated in the laboratory, and consequently it is still just as necessary for the

engineer or the college-trained man to get practical knowledge in addition to theoretical knowledge before he can do effective investigational work, but the extent of this practical training has been greatly reduced.

The broader the working knowledge of the field being investigated, the larger is the stock of ideas, rules, and principles, and the greater the capacity for devising new combinations. Ideas which have worked in one plant suggest themselves in connection with similar problems in another plant. The investigator who possesses the background of considerable practical experience has at his command valuable resources ready to draw upon when needed.

But experience, while it is extremely valuable, also contains an element of danger; especially when the individual has specialized continually along a certain line. Through constant association with certain recurring conditions, he forms certain habitual reactions and is often unable to see where improvements are possible. It is an old saying that "a new broom sweeps clean," and this is especially true in business and industry. Almost any method or process which has been handled in a given way for a considerable period of time can well be investigated by some one who is not so close to the work, that he will be able to see where changes are advisable. Often a rank outsider can come in and see places for improvement that those who were most intimately associated with the work could not see.

FORMING INFERENCES

Constructive imagination and practical experience form the basis for the development of useful suggestions regarding any problem which may come before the attention. Presupposing, then, a sufficient degree of both of these, we will now pass to a discussion of the principal methods of forming inferences, which are:

1. Through the systematic trying of new combinations of known facts;

2. Through generalization;
3. Through analogy.

1. *The Systematic Trying of New Combinations.* The essential function of inference is to form new combinations of known facts, and that being the case we may naturally expect that one of the simplest ways to develop suggestions is by trying new combinations. This is absolutely true, and if one has time and patience enough, and tries enough combinations, he will succeed in finding the correct solution.

But if he sets out without method or system to try combinations, he can easily consume an entirely unreasonable amount of time and get nowhere. It is therefore essential to adopt a definite method, thus restricting his effort to the consideration of those combinations which seem most feasible.

HELPFUL RULES FOR DEVELOPING IDEAS

The development of practical suggestions comes hard for the inexperienced investigator. In his previous work he has been accustomed to routinize his thinking, and the formation of new ideas is something quite new to him. In training research men to a greater capacity in developing ideas, the following simple rules have been found practical:

"(*a*) *Make a definite start.* Do not wait for inspiration. Force the attention on the subject. This starts the mind to functioning and ideas will begin to occur.

"(*b*) *Question everything—analyze.* This is the keynote of discovery or invention. There is nothing like questions to arouse the sleeping mind and start it working. Every one engaged in investigational work can gain inspiration and practical help from a study of the Socratic Dialogues. Socrates capitalized the faculty of asking questions, and the success of every great leader and teacher is based on that ability.

"(*c*) *Write down the ideas as they occur.* If one is inter-

ested in a subject, many helpful ideas will come to him at various times, seemingly quite unconsciously but actually they are the result of the conscious effort which he has started by directing the attention to the problem. These ideas often will come when one least expects them, many times in the night, while relaxing, after a good dinner, and so forth. One engineer keeps a dictating machine at his bedside, and when valuable suggestions come to him he dictates them to the machine and has them transcribed for future reference the following day.

"(*d*) *Talk the problem over with some one.* It is remarkable how the effort to discuss one's ideas on the subject stimulates the mind to further action. In the course of the discussion, as a result of such stimulation without perhaps receiving any definite hints or suggestions, the solution will come to him. This is the basic principle underlying conferences.

"(*e*) *Relax occasionally.* The mind grows stale when continuously forced to the consideration of a problem. When a noticeable lack of progress becomes evident, turn to something else. Then suddenly, like a flash, an idea or a possible solution will often come, seemingly unconsciously. How often has one vainly attempted to recall a name, only to have it pop into his head sometime later when he was thinking of something entirely unrelated.

"(*f*) *Stick everlastingly to it.* Because the value of relaxation is emphasized by no means implies that it is any the less essential to be persistent in the effort to develop suggestions. Quite the contrary. Valuable ideas most frequently come slowly. It may be necessary to go back again and again over the problem before a feasible plan, idea, or solution comes to mind."

These are but a few suggestions on stimulating ideas, which the writer has used for years and found practicable. Others will occur to the reader which perhaps fit his own case better. The best plan is the one which works, and so

the methods which help one to form inferences or suggestions about a subject are the best for him to use regardless of what they are.

2. *Generalizations.* Generalizations are another common means of forming inferences. Ordinarily, generalization is spoken of as the simplest form of reasoning. However, in view of the fact that the products of generalization are not certainties and often not even probabilities, it seems better to class this process under inference rather than under reasoning, so far as investigational work is concerned.

Generalization is based on the assumption which has been borne out in experience, that things which resemble each other in several of their attributes or qualities will probably resemble each other in other attributes. Generalizations, therefore, do not result in certainty, only in probability, and herein lies the danger in making use of them.

Of course, if a complete analysis of the observed facts has been made, then the conclusion is certain, but this rarely occurs. In most cases one must reason from selected instances, and, therefore, the accuracy of his generalizations depends almost entirely upon the representative character of the facts selected.

Sampling is a common example of generalization. Selected samples of a carload of wheat, a shipment of steel or ore, are made and tested. If this selection is made carefully, it is probable that whatever is true of the samples is true of the entire shipment. Throughout every investigation, generalizations are constantly used, but at all times the product must be accepted not as final, but simply as suggestions.

The process of classifying is primarily based on generalization. Certain resemblances are noted between the facts, and they are grouped accordingly. No sooner are they grouped in a certain manner than further generalizations occur, leading to inferences as to added properties, characteristics, or attributes because of the relation which has been noted.

It will not be necessary to devote much consideration to generalization, inasmuch as it is so commonly used. We are constantly tracing resemblances, real or fancied, between ideas or objects. What distinguishes every successful executive is largely his ability to generalize effectively. In fact, most executive decisions are based on generalizations and their effectiveness largely depends upon the extent of the knowledge possessed by the executive regarding the matters compared or contrasted.

Generalization is one of the principal faculties of the mind, but great caution should be exercised in utilizing it. There is little need for an incentive to generalize, rather the ability to curb it is needed. Every mind must generalize, but combined with this must be the certainty that the elements on which the generalization is based are fundamental. Otherwise, hasty and superficial generalizations result, and these inevitably lead to error. The ability to form sound generalizations is one of the most valuable assets that any man can possess.

3. *Analogy*. Analogy differs from generalization in that the inference is from likeness in many points to likeness in other points. The *qualities* are numerous in the case of analogy, the *objects* themselves in the case of generalizations. For instance, the manager of the upholstery department of an automobile company, while attending a convention of one of the technical societies, visited a large collar and shirt factory. While going through the plant he observed, with great interest, the methods used in cutting cloth. Seeing the analogy of cutting cloth to the cutting of leather, he went back to his concern and developed a plan for cutting leather similar to the method used for cutting cloth which he had observed in the collar and shirt factory. That his inference from analogy was sound is evidenced by the fact that within a few weeks' time the output of cutting per man was doubled, at the same time securing a 5% reduction in waste.

The basic characteristic of analogy is the relating of cer-

tain facts to other facts gained in a previous experience, which seem to be identical in character and inferring a similar judgment regarding them. As in the case of generalization, this is frequently considered as a method of reasoning, but here, again, the products are not certainties and often not even probabilities. Therefore, we can only consider them as suggestions or inferences.

Analogy is typical of a great deal of ordinary routine thinking, and is accurate in so far as the facts compared are identical. However, in actual practice it is very seldom that the conditions are identical, and the conditions which have not been noted may be sufficient to make the inference entirely wrong. The way to make sure that analogy or routine thinking is accurate is through making certain that the points of similarity noted are fundamental, which may be done by asking the following questions:

(*a*) Are the facts on which the analogy is based really true?
(*b*) Are the essential points of comparison or contrast absolutely identical?
(*c*) If not identical, do the points of similarity outweigh the points of difference?
(*d*) Is the inference drawn from analogy verified or discredited by other kinds of proof?
(*e*) Is the fact known to be true of the analogous case, even more likely to be true of the case in question?

There can be no doubt that many problems have been solved by following hints received from analogy. Whenever a fact is observed, the first impulse of the mind is to connect it with another which is similar. If anything were encountered that had no analogy to anything else, it could only be studied in a haphazard manner.

SUMMARY

Summing up the discussion of inference, no means as yet has been found for training a person to be inventive or fertile in his suggestions. If he does not have some con-

structive imagination, or if he possesses no experience in the work which he is investigating, he will probably not be able to develop any workable ideas.

But, assuming, that he has both, to a reasonable degree, then by making a systematic effort to formulate suggestions, he can stimulate the flow of ideas materially. In doing so, he will at all times find it helpful to bear in mind the value of: (1) making a definite start, (2) asking questions, (3) writing down the ideas as they occur, (4) talking over the problem with some one, (5) relaxing occasionally, and finally (6) sticking everlastingly to it.

On the other hand, every one utilizes generalization and analogy, and if these are combined with sufficient knowledge and experience, many helpful suggestions and possible solutions will be developed. But no matter how they are developed, all inferences must be subjected to an orderly inspection through reasoning, which in turn leads to the formation of other inferences and finally results in a conclusion or solution.

XVI

DEVELOPING THE CONCLUSION

Reasoning the transitional step between inference and conclusion. Function of reasoning. Types of reasoning: (1) inductive; (2) deductive. Basis of inductive reasoning. Procedure of inductive reasoning. Mill's Canons: (1) method of agreement; (2) method of difference; (3) joint method of agreement and difference; (4) method of concomitant variations; (5) method of residues. Suggestions on the use of inductive methods.

REASONING represents the transitional step between inference and conclusion. Valuable as suggestions are, they only represent useful ideas or possible solutions. Before the possibility becomes a certainty or even a probability, it must be weighed, considered, or tested in an orderly manner, which is known as reasoning. Failure to apply rigorous inquiry into the practicability of inferences is bound to result in error.

Reasoning is a constructive process which views the idea suggested from all sides. Its purpose is to find out the grounds which justify it and to estimate the consequences which are liable to happen if the idea is accepted.

Reasoning is frequently described as mental exploration, as distinguished from motor exploration, which characterizes much of the procedure of drawing inferences or evolving suggestions. The distinction between reasoning and inference is clearly brought out by John Dewey in *How We Think:*

We begin with a summary assertion that deliberation is a dramatic rehearsal (in imagination) of various competing possible lines of action. It starts from the blocking of efficient overt action, due to that conflict of prior habit and newly released impulse to which reference has been made. Then each habit, each impulse, involved in the temporary suspense of overt action takes its turn in being tried out. Deliberation is an experiment in finding out what the various lines of possible action are really like. It is an

experiment in making various combinations of selected elements of habits and impulses, to see what the resultant action would be like if it were entered upon. But the trial is in imagination, not in overt fact. The experiment is carried on by tentative rehearsals in thought which do not affect physical facts outside the body. Thought runs ahead and foresees outcomes, and thereby avoids having to await the instruction of actual failure and disaster. An act overtly tried out is irrevocable, its consequences cannot be blotted out. An act tried out in imagination is not final nor fatal. It is retrievable.

Each conflicting habit and impulse takes its turn in projecting itself upon the screen of imagination. It unrolls a picture of its future history, or the career it would have if it were given head.

TYPES OF REASONING

To a very great extent, the ability to solve problems depends upon the ability to estimate the relative value of inferences, and reasoning is the orderly procedure of determining these relative values. Reasoning takes two forms, which are known as inductive and deductive reasoning.

Inductive reasoning is based on the axiom that "What is true of the many, is true of the whole." It is the experimental method wherein, through deliberate methods of inquiry, we examine into inferences and suggestions, so as to ascertain the true cause of certain effects noted or the effect which will be produced by certain known causes. This is known as "finding the causal relationship."

In deductive reasoning the procedure is the reverse. Deduction is also based on an axiom that "What is true of the whole, is true of the part." The inference which is established through inductive methods is assumed as true and taken up as a hypothesis. Other facts are then gathered and successively related to this hypothesis. If the hypothesis successfully accounts for all the facts, it is considered as true.

Reasoning, except in isolated instances such as a theorem in geometry, is neither exclusively inductive or deductive. It is a combination of the two. In the investigation of

business problems, almost always, the reasoning is inductive at first, until a probable hypothesis is developed and then this hypothesis is tested deductively, and this is the order in which they will now be considered.

INDUCTIVE REASONING

Inductive reasoning is based on the assumption of the "uniformity of nature," or, to quote Basonquet, "The universe is a rational system, taking 'rational' to mean not only of such a nature that it can be known by intelligence, but, further, of such a nature that it can be known and handled by our intelligence."

In other words, it is assumed that our knowledge must be consistent with itself, not only as part to part, but also as parts to the whole. It follows directly, therefore, that every observed fact is produced by some cause, and that this cause can be located and made a part of our general knowledge. The function of induction is to discover the law which expresses the essential and universal relations existing between various observed facts.

Induction is, therefore, peculiarly the form of inference which is most valuable in investigational work. Through induction we thoroughly examine and analyze all the facts or suggestions bearing on the problem, and formulate hypotheses which explain the causal relationship between these facts. This leads to the formation of satisfactory conclusions or solutions, thus considerably broadening our knowledge and adding to our experience.

The process of inductive reasoning is a procedure which takes specific instances and suggestions, possible solutions to the problem, or explanations of the facts, and discovers the law which underlies, causes, or governs them. At this point it may be brought forward that generalization and analogy perform the same function.

While this is true to a certain extent, yet the results of generalization and analogy are only possibilities, or, at the

utmost, probabilities. Hence we can only consider that from a practical view-point they produce valuable ideas or suggestions, but do not really constitute inductive reasoning.

There are cases, however, of generalizations which must be considered as more than mere suggestions. This is true when a complete enumeration of the instances can be made. In other words, if the collection of the facts relating to any given matter is complete in every respect, the generalization, to all intent and purposes, represents a logical conclusion.

In like manner, if two instances are identical in characteristics and qualities, then the reasoning from analogy may constitute a valid conclusion. Actually, however, it is very seldom possible to make such a complete collection of facts; nor is it usually possible to ascertain beyond a shadow of doubt that the instances observed are similar in every single respect. Because of this doubt or uncertainty, therefore, it is best, for our purposes, to consider that the results of generalization and analogy merely constitute useful suggestions or inferences, which must be further subjected to orderly processes of reasoning before the conclusion is entirely established.

The distinction, therefore, between inductive reasoning, on the one hand, and generalization and analogy, on the other, is largely one of degree rather than kind. In the former the inspection and examination of the facts is rather casual or cursory. In the latter the examination is thorough and analytical. The end in view, in inductive reasoning, is to separate complex data into their various elements, so that the causal relation is disclosed, whose existence may be concealed by the very complexity of the facts.

In cases where the facts in question cannot be analyzed and the causal relation be revealed in this way, the most likely cause for the effect in question is tentatively accepted as the real cause. It is then used as a hypothesis until it has been tested or proved, when it becomes a conclusion.

Inductive reasoning is therefore the basis for the development of solutions to the usual business problem, and it is therefore this type of reasoning that the investigator should cultivate. Before proceeding to discuss this more fully, it may be well to summarize briefly some of the important facts as to generalization, analogy, and inductive reasoning which have been mentioned.

In the first place, all three are based on the assumption that whatever occurs has been produced by some cause. In generalization this cause is only vaguely assumed. The force of the generalization has been determined rather by weight of numbers than close analysis of essentials. In analogy the underlying cause is more definitely in the foreground, since analogy is based on the assumption that similar effects have been produced by similar causes. The greater the agreement of the qualities, therefore, the greater the probability that the cause will be similar. The similarity of the lightning flash to the electric spark suggested to Benjamin Franklin that they were due to a like origin, and his discovery was based, therefore, on analogy.

In scientific induction the causal relation is at all times in the foreground, and the search for it characterizes the entire procedure. In view of the fact that the prime purpose of the investigation as a whole is to bring out the causal relationships so that a satisfactory explanation, conclusion, or solution may be reached, it follows, therefore, that it is upon scientific induction rather than generalization or analogy that the investigator must depend for his conclusions.

Generalizations are the least trustworthy of all forms of inference. While of value, therefore, in providing suggestions for further testing through scientific induction, great care must be taken not to place too high a valuation on them.

Also, analogy, unless confirmed by experiment, has no real value as a means of inference. It also is of value in suggesting possible avenues for further consideration through scientific induction, but no more.

Induction is therefore the only safe method of discovering the true causal relationship, which, when discovered, becomes either the conclusion or leads to the solution of the problem. The discovery of the causes which have produced the effects we have observed is not as easy as it might seem. Facts are complex in character, and even between those seemingly alike, a variety of relationships may exist, as is evident from the study of any standard text-book on logic.

Inductive reasoning consists, as stated before, of an orderly method of bringing out the causal relationships which exist between the facts. It may, on the one hand, take the suggestions which have been offered as the result of a systematic trying of new combinations, or through the formation of tentative explanations of the facts, or solutions to the problem, through generalization and analogy, and subject them to further tests in order to verify their adequacy. On the other hand, we may proceed immediately to reason inductively about a problem without utilizing generalization or analogy; or, again, we may utilize these two forms of drawing inferences at various times during our process of reasoning in regard to the facts.

PROCEDURE OF INDUCTIVE REASONING

In general, however, the procedure of reasoning inductively consists of testing the facts in the light of certain definite laws of causal relationship which were formulated many years ago by the English philosopher, John Stuart Mill, and which have come to be universally known by his name. These laws of inductive reasoning are the following:

1. The Method of Agreement;
2. The Method of Difference;
3. The Joint Method of Agreement and Difference;
4. The Method of Concomitant Variations;
5. The Method of Residues.

These inductive methods will be found thoroughly discussed in any standard text-book on logic, and should be thoroughly mastered by every student of business problems. Inasmuch, however, as the usual presentation of these methods is primarily to the college student rather than to the business man, it has been found desirable to summarize these methods briefly from the standpoint of their application specifically to the investigation of business problems.

In other words, eliminating the purely technical aspect of inductive reasoning, and applying it directly to practical purposes, we find that the essential points involved in these methods are those which will be brought out in the following discussion.

1. *The Method of Agreement.* The method of agreement has been stated by Mill substantially as follows:

> If two or more instances of the phenomenon under investigation have only one circumstance in common, the circumstance in which alone all the instances agree is the probable cause of the given phenomenon, or sustains some causal relationship to it.

Stated another way, the method of agreement consists in inferring the existence of a causal relation when, in a number of varying instances, it is observed that the supposed cause is always accompanied by the phenomenon in question, or that the supposed effect invariably follows. It is obvious that in a series of observations those elements which are constant in all must be considered as connected in some manner with the cause of the phenomenon, while those which are variable—that is, occurring in some cases and not occurring in others—cannot be considered as playing an essential part, either as a cause or as an effect.

A simple example of forming a conclusion through this process is the following: A certain concern desired to find out why its sales were falling off in one line. A questionnaire sent to the sales force brought many replies, some giving several reasons, but all gave as a reason the fact that the trade was giving preference to a competitive product

which was nationally advertised and did not require so much sales effort to move. Although many were the reasons given, all salesmen agreed on this fact which led to a study of the market and competition and, eventually, a correction of the condition.

In reasoning by the method of agreement, it is of great importance that the instances selected for observation or experiment be as varied as possible, so that widely differing phenomena may be gathered together. Then, if running through them all one common element is observed among the antecedents and one common element among the consequences, the greater the variation among the instances the more pronounced will be the significance of the constant elements.

In many cases, the determination of this constant element is a process of elimination, as, for instance, in the previous case, several reasons could have been considered. In that way, the unessential elements are eliminated, and the essential element which remains is emphasized.

In another form this consists of the exercise of discrimination—that is, being able to see the constant element under all the changing forms which it can assume. In this respect, the method of agreement is essentially the way in which concepts of any kind are formed. In other words, we note the essential elements of the thing we are observing, and bring these together in the concept that we form.

As a consequence, the method of agreement is better adapted for use in observation than it is for experiment. Instances cannot always be manufactured. Especially is this true of many of the facts which are observed in the conduct of an investigation, and it is therefore beyond the power of experiment to reproduce them. They can, however, be the objects of research and the application of inductive reasoning through the use of the method of agreement.

This method of inductive reasoning, however, is open to criticism at several points, even when the observations

have been accurate, and accidental or unessential elements eliminated, so that at the start it must be admitted that it does not rank as a final method. Rather, as brought out before, it must be considered in connection with certain of the other methods, hereafter mentioned, particularly the method of difference, in order to either confirm or disprove the apparent conclusion which may be developed through its process. The chief criticisms made of this method may be summed up as follows:

(*a*) The cause indicated by the method of agreement may not necessarily be the sole cause of the effect noted. The fact that in a number of instances hard times have been preceded by extensive crop failures does not by any means prove that the crop failures have produced hard times, although they may have been a contributing element.

(*b*) In practical experience while it is possible to recognize a common element in most, if not all, the effects noted, nevertheless it is not so easy a matter to distinguish the common element in the corresponding causes which have produced these effects when the method of agreement is used alone. This is quite true, and that is the reason why, in all cases, the method of difference should be associated with the method of agreement, so as to bring up the differences and thus isolate the true causes.

(*c*) The element which seems to be constant in the observations of instances noted may nevertheless prove to be an unessential accompaniment in every case. The fact that best quality work in many instances is produced by workers who do not rank high in volume of production does not indicate that low producers always turn out good quality work.

(*d*) In many other cases, also, while a constant element does exist, nevertheless the corresponding effect does not occur in every instance, due to some neutralizing element which has not been observed. In making changes in de-

partmental procedures, this situation comes up constantly. Through the method of agreement it seems certain that the introduction of a certain improved method must result in increased production. However, the method when introduced is neutralized by a negative attitude of certain individuals, and thus the desired effect is not secured.

After all, then, taken alone the chief function of the method of agreement is to provide suggestions of possible, and at best, probable, causal relationships between the facts observed. The method of agreement has been described in considerable detail largely because much of our inductive reasoning assumes this form. Whenever different observations present characteristics of a similar nature, we are led at once to suspect a causal relation and to inquire further into this relation. Too often, however, the supplementary inquiry is omitted and we satisfy ourselves with a few surface resemblances that lead to a hasty conclusion which is neither precisely nor adequately determined.

2. *The Method of Difference.* The method of agreement, as has been seen, does not produce in most instances any certainty as to the conclusion reached, but only a probability. The certainty of this conclusion is established by the method of difference. Through this means, in a given instance which is being studied, the supposed cause is withdrawn, or its force eliminated. If there is an immediate disappearance of the effect, then a causal relation between the two is assumed as proved.

This method is stated by Mill as follows:

> If an instance in which the phenomenon under investigation occurs and an instance in which it does not occur have every circumstance save one in common, that one occurring only in the former; the circumstance in which alone the two instances differ is the effect or the cause, or a necessary part of the cause of the phenomenon.

An interesting instance in point occurred some years ago in a shop engaged in war work. In the machine-shop a bonus system was installed, to encourage maximum pro-

duction. Very shortly after this bonus system was put into operation, it was observed that one old fellow almost immediately increased his production out of all comparison not only with what he had formerly gotten out, but also with the volume produced by his fellow-workers, who were engaged on exactly the same kind of work.

Now machines, type of work, working conditions, and everything else except the individuals were seemingly identical, and in the case of the individuals this particular worker was just about the average. It was evident that the increased output was not due to any extraordinary ability on the part of this operator, but must be due to some other cause. After some study it was finally discovered that the cause lay in a special type of bit that this operator was using on his machine.

In figuring the bonus the engineer had based it upon a standard number of pieces which could be produced by using the quality of tool steel that it was possible to secure at that time. In his tool-box at home, however, this particular operator had several pieces of tool steel that he had brought over from the "old country," which were considerably harder than it was possible to obtain in the open market at that time. Because of the better grade of steel in his bit he was able to run his machine at a faster rate and take off a larger bite than was possible with the standard tools which were in use, and, therefore, he produced a larger volume of output.

The method of difference, then, is essentially one of negation. It is preeminently the method of experiment rather than observation, inasmuch as it is only by experiment that we can control the forces or materials, and that we can introduce changes, so as to establish the real causal relation. The method of difference, therefore, cannot always be used to test the conclusions formed from reasoning through the method of agreement, but other methods must be used in cases where observations are concerned, and where experimentation is not possible.

The method of difference is open to various criticisms which, as in the case of agreement, limit the certainty of the conclusions in some measure. The most important of these are the following:

(*a*) There is always the possibility that one may be misled in supposing that two instances are precisely alike with the one exception of the presence or absence of the supposed cause, whereas in reality these instances differ radically but he has not been able to note this difference.

It has been frequently observed that the changing of a method will very frequently result in improvement in quality or the volume of work. This is not at all due to the fact that the method is necessarily any better, but rather because in the previous operation the mind was not entirely upon the work but very probably engaged in thinking of other things. With the change in method came the necessity of concentrating closely upon the work at hand, with the consequent improvement in the quality or the volume of the work.

(*b*) In other instances it has been objected that while this particular method may indicate the particular cause for the effect which is noted in this instance, it does not furnish any basis whatsoever for a wider generalization that the effect in question is always produced by this cause. The example has often been used to illustrate this that because an epidemic of typhoid fever has been traced to the drinking of impure water it does not necessarily follow that every time impure water is drunk typhoid fever will result. Other modifying circumstances, such as the condition of the body, power of resistance, and so forth, may intervene so that the effect in question may not follow at all. This brings out the fact which has been stated before, that no one of these methods stands by itself alone, but that every one must be taken in connection with others before any conclusion can be accepted as entirely proved.

(*c*) Another time when the method of difference may

result in error is in cases where the supposed causal element is regarded as the entire cause, when in reality it may be but part of the cause. This is a common occurrence in drawing conclusions from the study of industrial conditions, inasmuch as there is such an interrelation between various elements that it is frequently impossible to isolate the one cause, and the best one can do is to discover a number of related causes, each of which plays a part in producing the effect which is observed.

From the foregoing, it is plainly apparent that the failure to observe certain facts by no means proves their non-occurrence. As there are sounds which we cannot hear, and light waves which we cannot see, so it is not safe to assume that certain effects have not been produced or causes operative simply because we have not observed them.

In order for a negative argument founded upon the non-observation of facts to have any considerable weight, it must be fully demonstrated that the object, if existent, would have been observed and it is this probability that defines the value of the negative conclusion.

3. *Joint Method of Agreement and Differences.* Because of the foregoing difficulties in applying the method of difference alone, the joint method of agreement and difference has been developed. It is stated by Mill, as follows: "If several instances in which the phenomenon occurs have only one circumstance in common, while several instances in which it does not occur have nothing in common save the absence of that circumstance; the circumstance in which alone the two sets of instances differ is the effect or the cause or an indispensable part of the cause of the phenomenon."

The method of agreement, it will be recalled, requires two cases differing in every respect, except that the causally related element is present in both. In the method of difference, the two cases must be alike in every respect, except that in one, a certain effect and its cause are absent. In both, therefore, the accuracy of reasoning depends much

on the certainty that all the points of agreement or difference have been noted.

In most cases, especially in business problems where human actions are under observation, it is often impossible to utilize either the method of agreement and difference, because other points of resemblance or difference are noted and no two cases can be found wherein other elements do not enter.

In order to reason back to the causal relationship in these cases, the joint method of agreement and difference has been developed. Practically, this method is an extension of the method of agreement and is the best one to use whenever the latter fails to furnish a definite result. The joint method, while not producing as certain a conclusion as the method of difference, yet tends to indicate the true cause when the instances compared have been carefully selected.

4. *The Method of Concomitant Variations.* "Whenever a phenomenon varies in any manner, whenever another phenomenon varies in some particular, it is either the cause or effect of the phenomenon or connected with it through some form of causation." Often in observing facts, it is noted that as one factor increases, another increases or decreases in proportion. As the volume of output increases, the unit costs may decrease. The larger the volume of sales, the larger the gross profit, and so forth. Between these, there seems to be a correlation, but it is not certain whether the one is the cause or effect of the other.

The seeming correlation may be only apparent and, therefore, it should be subjected to a careful test, in order to make sure that the variations are not due to some other cause which has not been observed. This testing is accomplished by so modifying the given instance that the supposed cause will vary in intensity. Then if the effect varies in a corresponding manner, there is evidence of a causal relationship between the two.

This method is especially valuable whenever the strength

of the forces utilized can be varied at will and effects clearly seen. It is especially useful in statistical work, being at the basis of group comparison. In using the method of concomitant variations, it is necessary to observe the following precautions:

(*a*) It does not necessarily follow, although two items have been seen to vary in a certain way over a certain point, that they will continue to do so at the same rate. The introduction of an incentive in the shop will produce an increase in output up to a certain point, or it will cause a reduction in unit costs to a certain point, but there it seems to stop. In other words, for most variables there is a breaking point, and this is especially true of all variables wherein the human element plays an important part.

(*b*) It sometimes happens that continued increase of the force produces effects which neutralize the effects desired. Driving, for instance, will produce increased effort up to a certain point, when the effect is neutralized by the feeling of resentment aroused in the individual, and from that point on a decrease usually develops.

(*c*) Two things may vary together but neither be the cause or effect of the other, both being related to some other cause. For instance, in one factory certain changes were made in the lighting, and a remarkable reduction in the accident rate was soon noticed. At first glance, it seemed that the reduction of accidents was due entirely to better lighting, but on digging into the matter further it was found that it was principally occasioned by more effective instruction of operators, a training course having been inaugurated just prior to the time when the changes in lighting were made.

5. *Method of Residues.* This method is very clearly stated by Mill, as follows: "Subtract from the phenomenon such part as is known by previous inductions to be the effect of certain antecedents and the residue of the phenomenon is the effect of the remaining antecedents." It

is the method of elimination of known relations so that the unknown causal relations may be disclosed.

The method of residues seems at first somewhat like that of the method of difference, but this is not the case, for in the method of difference direct observation discloses what happens when the residual cause is not present. In the method of residues we cannot and do not see the effect which is produced when the known causes are eliminated. We can only calculate the effect indirectly, basing our calculation upon what we know of the way in which the items eliminated behave when they are present separately.

The method of residue is open to two dangers:

(*a*) That in eliminating points one may overlook the combined effect of some other causes and thus emphasize too much the remaining cause. A disturbance is heard in a room in which three persons are present, A, B, and C. A and B are both known to be very quiet and of even dispositions, while C is inclined to be rather truculent. In the process of residues we would eliminate A and B from consideration as the cause of the disturbance and assume that C was responsible for this. In doing so, we might overlook the fact that although A and B, when separately considered, are of very mild dispositions, yet there is something about their make-up which provokes hostility, and it was this combined effect which created the disturbance.

(*b*) That one overlooks some circumstance which is really present, thus attributing a false value to the presence of something else. This type of error is always present and must be guarded against.

The well-known principle in management known as the "exception" principle is based primarily upon the method of residues. In considering a number of facts, such as an output report of different departments, the executive takes no note of those effects which are running along the line expected, but centers his attention upon those which seem out of line.

Each of these five tests applies to different types of facts. Some are best used in connection with observations, others work best with experiments. In some cases, in order to achieve accuracy, the particular causes or effects must be capable of being physically removed or controlled. In other cases, the effect of such changes of elimination can be estimated or other elements substituted, which will enable a satisfactory estimate to be made.

The point to be drawn in is that in inductive reasoning the inferences are subjected to such definite tests as the facts themselves require, in order to demonstrate the soundness of the conclusions which will be drawn from these inferences.

SUMMARY

Inductive reasoning, as stated before, is that method of testing the soundness of inferences or suggestions through the comparison and observation of a number of instances and from this observation developing a general law which satisfactorily explains all or most of the facts.

Most of the facts to be considered cannot be handled or measured quantitatively but have to be considered from an abstract standpoint. In testing conclusions of this character, the methods of agreement, difference, joint method of agreement and difference, concomitant variations, and residues are essential.

When the facts can be weighed or measured quantitatively, the use of experiment becomes possible, and the measure of results obtained is in proportion to the number of observations and the care used in selecting those which are typical.

In conclusion, however, it must be remembered that even the most simple business problem is highly complex. It is practically impossible to isolate any condition from the influence of the personal equation. This is what makes it so difficult to express industrial and commercial relationships with anything like the exactness of the chemist or

scientist. For instance, the demand for a particular commodity may be fairly closely determined under certain conditions. But let a society leader, incidentally perhaps, start a fad, and the results may be absolutely changed overnight.

XVII

ESTABLISHING THE CONCLUSION

Formulating the hypothesis. Testing the hypothesis. Deductive reasoning. Syllogisms. Laws of deductive reasoning. Fallacies: (1) failure to define terms; (2) inaccurate observations; (3) inaccurate reasoning. Begging the question. Hasty generalization. Summary of thinking process. Working out the solution. Charting the analysis. Testing the validity of a hypothesis. Practicability essential at all times.

Up to this point in the investigational procedure, the movement of thought has been constantly forward toward the development of the conclusion. Now begins a backward movement designed to verify or establish this conclusion as adequate. This completes the cycle of thought.

Suggestions and inferences furnish a possible solution. Inductive reasoning, aided when possible by experiment, furnishes a tentative conclusion called a hypothesis. Now comes the testing and verification of that hypothesis, which is accomplished through the aid of deductive reasoning.

Right at this point the question may perhaps be raised, "Does deductive reasoning serve no other purpose in the conduct of an investigation than to prove or disprove hypotheses secured through inductive reasoning?"

There are occasions and types of investigations where it is possible to relate the facts directly to an established principle and formulate the conclusion at once without the aid of inductive methods. For instance, in the course of the preliminary survey of one machine-shop, the engineer noted that the tools used on a certain line of boring mills were not ground to the shape that experience had shown to be best for that work. As a result, he was immediately able to form the conclusion that production could be materially increased on these machines by standardizing the grinding of tools in accordance with accepted practice.

While numerous examples could be given of conclusions which have been reached without utilizing suggestions or inductive reasoning, yet in the main investigations in the field of business follow the procedure which has been laid down in the preceding chapters. The part which deductive reasoning plays in this procedure is largely, if not wholly, that of testing or verifying hypotheses which have been developed inductively.

Stated another way, the process of thinking is in itself an investigation. Starting out with a motley array of facts gathered from every available source, definition and classification reduces them to a semblance of order. Memory brings up images of related facts, enabling comparisons to be made between the new and the old. Judgments are formed, based on essential identities noted even amidst diverse circumstances. From the judgments are derived suggestions and inferences based on the law that what is true of one thing is true of its equivalent. Thus gradually a tentative conclusion takes form which is known as a hypothesis.

FORMULATING THE HYPOTHESIS

At first, this hypothesis may not assume a tangible form. It may be somewhat vague and abstract, but with each added experiment or application of inductive methods it gradually assumes more definite shape. Just as soon as is possible, the proposed hypothesis should be put into words. So long as it exists only in the mind, it is an abstraction. Putting it into words makes it concrete—something that can be seen, felt, and handled.

Formulating the hypothesis in definite terms serves two distinct purposes. First, it clarifies the idea. The necessity of expressing an idea in words forces clear definition and classification of terms. In the second place, the definite formulation of the hypothesis makes possible the establishment of its truth or falsity.

In formulating the hypothesis, the central thought at all times must be that of so shaping or wording it that it is subject to verification. No matter how interesting a conclusion may be, if it cannot be tested out and verified, it is useless for practical purposes.

Another important point to be considered in formulating the hypothesis is that of stating it in as simple terms as possible. Nothing is gained by using terminology difficult to grasp. The investigator himself may understand what is meant, but in almost every case the products of his work must be approved or utilized by others, and hence it is the part of wisdom to phrase conclusions in such a manner that they will need little or no explanation as to what they really mean.

TESTING THE HYPOTHESIS

The final testing of a hypothesis or verification of a conclusion is accomplished through the use of deductive reasoning. As brought out in the preceding chapter, deductive reasoning proceeds from the general law, formulating judgments which are true because the general law upon which they are based is true. The syllogism is the external form assumed by deductive reasoning. A well-known example is the following:

1. All men are mortal;
2. Socrates is a man;
3. Therefore, Socrates is mortal.

The foregoing is an example of a positive conclusion, but a conclusion is just as apt to be negative. In fact, a very large percentage of the conclusions formulated from industrial research are of the negative type, which is typified by the following syllogism taken from the illustration given at the beginning of this chapter:

1. Tools ground to shape X produce best results on Y work;
2. These tools are not ground to shape X;
3. Therefore, these tools are not producing the best results on Y work.

In each of the foregoing examples it will be noted that there are three terms or factors considered and that there are three propositions formulated utilizing these three terms. The first of these propositions is known as the *major premise* in which is stated the general principle or law involved. The second is known as the *minor premise* and in it the point under consideration is related to the principle stated in the major premise. The third, or conclusion, is secured from the union of the major and minor premises and in it the general principle is held to apply specifically to the observation or statement appearing in the minor premise.

The procedure of verifying a conclusion deductively consists merely of setting up the hypothesis or explanation of the facts as a major premise. Related considerations or points are through the minor premise, then referred to this assumed principle, and, if the conclusion is true, it follows that the hypothesis itself must be true.

For example, the assembly work on a certain part was transferred to another part of the factory, and almost immediately a drop in production took place. As the same workers were employed, utilizing the same tools, workbenches, and equipment, it was felt that after they had gotten accustomed to the new location the work would be turned out as rapidly as heretofore.

However, this did not happen but, if anything, the volume began to drop off still further. Ascertaining the cause of this decreased production constituted the problem to be solved. Through the use of inductive methods, particularly the application of the joint method of agreement and difference, it was found that poor lighting facilities were probably the cause of the lessened production. Setting this up as a hypothesis, it was tested deductively through the use of a number of syllogisms in which eye strain, fatigue, and so forth, were related to poor lighting facilities and as it was undeniably true that these latter factors slowed up work, it followed that the hypothesis was true.

LAWS OF DEDUCTIVE REASONING

In applying deductive reasoning to the verifying of hypotheses, it is essential for the investigator to know the fundamental laws of deductive reasoning. While it is assumed that he has studied these in logic, it may be well at this time to restate them, as it is of the utmost necessity for him to know them thoroughly in order to draw accurate conclusions deductively. These rules are as follows:

1. A syllogism must contain three terms and only three. Each additional factor to be related to the general statement or proposition calls for an additional syllogism.

2. A syllogism must consist of three propositions and only three. The conclusion is a mathematical equation formed by combining the remaining elements in the major and minor premises after striking out the constant element. The introduction of an additional proposition would make this equation impossible.

3. The middle term of a syllogism must be distributed—that is, taken universally or in its whole extent of meaning—once at least in the premises. The middle term constitutes the term common to the major and minor premises and this rule simply means that in either one of the two premises, this term must be taken in its totality. If the principle, as stated, does not have universal application, the conclusion can only be a possibility or, at the utmost, a probability.

Herein lies one of the things which make it difficult to reason deductively concerning business problems. In the realm of science many principles and laws have been absolutely established which can be stated universally and which permit of no exceptions. In the industrial field, there are few such laws. Even the laws of economics, such as supply and demand, diminishing utility, and so forth, seem to fall down in particular instances.

It is quite true that figured over a long period of time

these laws hold up, but when a business man reasons deductively from them in connection with any particular instance, he cannot be sure of his conclusions because other factors such as style changes, seasonal conditions, and so forth, may have an overwhelming influence.

In fact, the diversity of conditions and the ever-shifting influence of the human element make it inadvisable, if not impossible, to set up any rules of action as universally applicable. Consequently, deductions from principles, laws, or rules of action which cannot be taken universally are only probabilities at the most and not certainties.

4. No term may be distributed in the conclusion unless it is distributed in the premises. This simply means that unless a term is taken in its entire extent in one of the premises, it cannot be taken in its entire extent in the conclusion. If only "some men were mortal," it would not follow necessarily that Socrates were mortal even though he were a man.

5. From two negative premises, nothing can be inferred even though both may be true. Throughout this procedure it has been constantly brought out that the failure to observe a certain thing means but very little. That "A machine cannot run without power" may be true, but when the minor premise is also negative, as "A tree is not a machine," there is no conclusion possible.

6. If one premise is negative, the conclusion must be negative, and vice versa, a negative conclusion can only be reached when one of the premises is negative.

The foregoing rules of deductive reasoning, however, simply make sure that the reason is deducted along proper lines. They do not necessarily guarantee the accuracy of the deduction. In fact, it is only too possible to draw totally unsound conclusions deductively, and that is one of the main reasons why inductive rather than deductive methods are preferred in seeking the explanation and true interpretation of observed facts.

FALLACIES

The formation of unsound conclusions, even after the rules of deductive reasoning have been carefully followed out, constitutes what is known as fallacies. Fallacies, of course, are apt to result from inductive reasoning, but the danger is not so great because no general principle is assumed as true but, rather, the observer is seeking the principle itself and formulates it from the behavior of the observed facts. Fallacies are nothing more or less than false reasoning, and this may take place on account of any one or all of the following reasons:

1. Failure to properly define terms;
2. Inaccurate observation;
3. Inaccurate reasoning processes.

All of these matters have been covered exhaustively in previous chapters and the investigator has been cautioned to be on constant watch lest any of these spoil his work. However, it may be well at this time to discuss briefly some of the principal types of fallacies, that is, errors in reasoning, which are apt to be encountered.

1. *Fallacies Resulting from Failure to Properly Define Terms.* This is one of the most frequent causes of inaccurate conclusions. The ancient fallacy:

1. No cat has two tails
2. Any cat has one more tail than no cat
3. Therefore, any cat has three tails

is a case in point, the illogical conclusion being entirely the result of the term "no cat" being used in two different ways.

In the chapter on "Definition and Classification," this subject is treated fully and if one is careful to make sure that his facts are clearly defined in accordance with the rules of definition given therein, and if he follows closely the laws of classification in arranging his data, he call feel certain that his conclusions will not err on this account.

2. *Fallacies Resulting from Inaccurate Observation.* Another common cause for inaccurate conclusions is inaccurate observation of the facts in question. Some of the principal forms which fallacies assume as a result of such inaccurate observation are the following:

(*a*) Assuming as a cause something which is merely another effect of the cause;
(*b*) Assuming as a cause something which as far as can be determined is associated with the effect merely by chance;
(*c*) Assuming as a cause something which is not a cause but simply an antecedent of the effect;
(*d*) Assuming as a cause something which actually operates after the effect has already obtained;
(*e*) Assuming as a cause something which is a partial cause of the effect, but which alone is inadequate to produce the effect.

Inaccurate observation may occur from two distinct causes. The first of these is, of course, physical inability to ascertain the true state of affairs. The evidence of a color-blind man regarding the signals showing at the scene of a wreck, would be absolutely worthless. In the chapter on "Personal Observation and Experiment," many helpful suggestions are given which will aid in making certain that the facts observed will faithfully represent the true state of affairs.

Inaccurate observation often results, however, from mental rather than physical disqualifications. Prejudices of various types color the facts as observed and often lead to the formation of conclusions which are absolutely unsound. It is probably true that prejudices, bias, and kindred mental influences can never be entirely eliminated; but if the observer expects to get at the real facts, he must curb any such tendencies on his part and truly endeavor to present the facts exactly as they are. The helpful suggestions and ideas given in the chapter on the "Proper Mental Attitude" will help greatly in curbing or controlling this influence.

The following experience of a large mail-order house will fully demonstrate the danger of fallacious reasoning of this type:

This establishment was in the market for a number of billing machines to replace equipment which had long since served its purpose. The purchase of these machines was put up to the purchasing agent. In accordance with his usual practice, he had a number of manufacturers submit samples for trial. Special operators were furnished by the competing concerns, and a two weeks' record was kept showing the quantity and quality of work done. Mechanical tests were made in order to determine the durability of the machines. The bids submitted were compared with the results of these tests, and the purchasing agent decided in favor of the machine which seemed to him to satisfy all tests most successfully.

No sooner was the first delivery made of the new machine than trouble began. It was found, first of all, that because of certain peculiar mechanical features it was necessary for the operators to greatly modify their typing motions, and that even the most expert were unable to get out much over half of the work expected. Coupled with that was constant complaint from the operators that the machine tired them out because it ran so heavy.

The management thought that this trouble would iron itself out as the operators became more familiar with the machines, but it did not. On the contrary, operators began to quit and the labor turnover assumed alarming proportions. Coupled with that it was found that there was no available supply of experienced operators for this machine, and that typists familiar with standard writing machines would not work at it.

Wage adjustments, a bonus system, a special training school for operators, and everything else the management could think of was tried, but the cost of writing orders remained excessive.

Had the purchasing agent, in the beginning, analyzed his

problem and determined the fundamental issues involved, he could then have made a real investigation of the different machines which would have brought out the objectionable points and thus avoided an annual loss of many thousands of dollars.

3. *Fallacies Resulting from Inaccurate Reasoning Processes.* Fallacies resulting from inaccurate reasoning are mainly of two kinds, known as:

(*a*) Begging the question
(*b*) Hasty generalization

(*a*) *Begging the Question.* When in order to prove a conclusion it is referred to another proposition that is assumed to be true but which itself needs verification, this type of fallacious reasoning is known as begging the question. This sort of fallacy can easily be discovered if the investigator makes sure that the first proposition is true and does not, itself, require proof. For example, a well-known sales manager used to base his decisions as to whether or not a man would succeed in selling his line of goods by checking up this man with a formula he had developed as to the physical characteristics which years of experience had demonstrated to be essential in his line of work. His judgment of any salesman could be expressed in the following syllogism:

1. A salesman to be successful in selling X goods must have Y characteristics.
2. This man does not have Y characteristics.
3. Therefore, he cannot sell X goods successfully.

From the standpoint of the rules of the syllogism, his reasoning was absolutely correct but the trouble lay with his major premise, which was unsound. In the field of management, especially in connection with the handling of men, there is much fallacious reasoning of this type. The only way to get rid of it is by making sure that the principles, laws, rules, or policies upon which deductions are based, are sound.

(*b*) *Hasty Generalization.* Hasty generalization, together with inaccurate reasoning from analogy which is closely associated to this, constitutes the most common error in reasoning. This occurs usually through forming inferences from consideration of only a few facts. The way to avoid such fallacious reasoning is through making sure that all inferences formed through generalization and analogy are tested inductively if possible.

A very large share of the mistakes made by early efficiency engineers were traceable directly to fallacious reasoning of this type. So are also the elaborate accounting systems which have been installed in many lines of business without a careful analysis in order to see whether such an elaboration was absolutely necessary.

For example, the comptroller of a corporation manufacturing engines and employing over 15,000 people was made the president of a concern manufacturing pumps, employing less than 1,000 people. Upon taking up his duties with the new organization he proceeded to install the accounting system used by the larger concern without changing the forms or methods. The same data were secured as in the larger concern, but due to the different conditions in the smaller concern they were of but little value. The force required to secure this information numbered about 40 people, which was over 4% of the total force employed. In the larger concern the force required to handle the accounting system was less than 2% of the total employees.

The increase in cost occasioned by this system was so great as almost to wipe out the profits for the period in which it was used. The board of directors hesitated to return to the previous system because it had proved to be totally inadequate; yet they could not afford to keep up the one which had been brought in. They called in an industrial engineer, who, after studying the conditions, devised a system especially to meet their requirements. But eight people were required to operate this system. It was so devised that all the necessary information needed for direct-

ing the business was furnished to the management. Not only that, but under the new system inefficiencies were uncovered which, when removed, resulted in an increase in profits to a point never before reached.

SUMMARY

Thinking as applied to a particular business problem essentially includes three distinct steps:

1. *Forming Inferences.* As the facts are gathered, classified, and tested, ideas or suggestions of possible explanations of those facts or solutions to the problem, come to mind. These suggestions are known as inferences and constitute the raw material of thought. They develop largely out of the background of experience possessed by the individual, coupled with the use of the constructive imagination.

2. *Inductive Reasoning.* This is a more formal process concerned with the scientific analysis of the suggestions or ideas developed in the previous steps. Inductive reasoning is carried out with the aid of certain established methods which have long been the basis of discoveries in the realm of pure science.

3. *Deductive Reasoning.* This represents the verification stage in which the hypothesis as produced by the combined action of (1) and (2) is tested in order to demonstrate its truth or falsity. Authorities generally assume that a hypothesis is verified when it accounts for all of the facts that are properly related to it. On the other hand, however, some extremists contend that before a hypothesis may be considered as absolutely verified, it must not only account for all of the facts, but there must be no other possible hypothesis to account for them.

For practical purposes, however, a hypothesis may be considered valid when it satisfactorily answers the following questions:

(*a*) Are the facts sufficient to warrant the inference?

(*b*) In case it is not possible nor practical to examine all the facts, has care been taken to make sure that fair examples have been taken for the spot test?

(*c*) Is there no further inference which could be logically reached from consideration of the facts?

(*d*) Have other and presumably important facts been left out of consideration?

(*e*) Is the apparent connection between the facts and the inference fundamental or is it merely incidental?

(*f*) Is the inference drawn from consideration of too few instances or from those which are not truly representative?

(*g*) Is the inference partly but not wholly true?

With the verification of the hypothesis, the cycle of thought is concluded, but not always is the problem solved. Perhaps the use of deductive reasoning may demonstrate that the conclusion is unsound. In that case, it is necessary to go back and (*a*) gather more facts, (*b*) form additional inferences regarding them, leading to (*c*) further use of inductive methods, and finally (*d*) verification of the new hypothesis deductively.

This procedure is repeated until an explanation of the facts or a conclusion is reached that is fully demonstrated as sound. With the establishment of the conclusion, the explanation of the facts, the determination of the cause that has produced the observed results, the fact finding or explanatory type of investigation closes. All that remains is to write up the report, properly presenting the conclusions established, and the work is done.

But in the advisory type of investigation, and business investigations are practically all of this type, the foregoing decisions simply represent the prelude to the still more important step of working out the solution. While it is true that a definite benefit attaches to the discovery of the cause for certain unsatisfactory conditions, and so forth, it is still more important to find out ways and means of accomplishing better results or of accomplishing equal results with less expenditure of time, money, or effort. This is the function of industrial engineering investigations, whether

conducted internally through the aid of a staff department or by a professional engineer brought in from the outside.

WORKING OUT THE SOLUTION

This step is not an independent step in the investigational procedure but grows directly out of the establishment of the conclusion. The very act of testing the conclusion inductively and deductively stirs up the constructive imagination of the investigator and leads to the formation of inferences as to the effects which would be produced if certain changes were made in basic conditions or certain other factors introduced into the problem.

And so the procedure of thought begins another cycle, this time striking out into new fields. However, the mode of procedure is the same; that is, new facts are gathered in connection with the new suggestions or inferences and these are analyzed and related to the problem through inductive and deductive methods, resulting in the formulation of a plan which seems basically sound.

Such a plan may not develop quickly; in fact, it may be necessary to go back over the cycle of thought repeatedly before a workable solution is reached. And even after a solution has been developed which is satisfactorily verified inductively and deductively, it cannot always be taken at its face value but requires further verification experimentally. Sometimes this is not possible, and in such cases the investigator, in setting up a solution, must be very certain of the soundness of the reasoning upon which it is based.

In cases wherever possible, the experimental test of the solution is advisable. In a way this is closely related to the application of deductive methods in that the solution is accepted as true and it is tried out in practice. If the results are satisfactory and conform to those which were expected, it is assumed that the solution is sound and will apply in all instances.

This stage of the investigator's work is one of the most

important of all. His value depends largely upon his ability to devise practical solutions to the problems he investigates. Almost any one with ordinary intelligence, following carefully the rules laid down in the preceding chapter, can gather accurate facts, classify, test, and interpret them correctly, and draw sound conclusions from their consideration. Not every one, however, has the power of vision, constructive imagination, or whatever you may call it, that enables him to see new methods and ways of doing things which will result in greater effectiveness.

The inventive faculty probably exists in every individual but in most it lies dormant. Thinking has been so routinized that independent action is rarely considered. Such an individual must be stirred up—his brain excited. He must be encouraged to think along new lines and the ideas brought out in the chapter on "Suggestion and Inference" will be found very practical in developing the inventive side of his nature.

The ability to work out practical solutions to business problems is largely acquired through experience. The more problems one tackles, the better the capacity for solving them, provided the individual possesses average intelligence. But granted the average intelligence and capacity to profit from experience, having a definite plan of attack when approaching a problem helps greatly in reducing it quickly to its elements and visualizing what is needed.

CHARTING THE ANALYSIS

For this purpose, the writer has often made use of the chart illustrated in Figure 8 in analyzing a problem. The use of this chart has two advantages: it concentrates the attention and visualizes the fundamental points.

It will be noted that this chart consists simply of four columns headed "Points to be considered," "What was wrong," "What should be done," and "Results to be expected."

Points to Be Considered	What Was Wrong	What Should Be Done	Results to Be Expected

Figure 8: Chart for use in analyzing business problems and visualizing solution.

Given any problem and a sufficiently large collection of facts bearing upon it, the first thing to do is to pick out the fundamental points to be considered. They may be outstanding conditions that are wrong and need remedying. They may be certain future considerations for which provision must be made. Regardless of their character, however, it clarifies the analysis to list them on the chart.

In the second column the analysis of conditions as found is carried one step farther. In the ordinary industrial engineering type of investigation, the work is usually done for the purpose of finding a better way to do the work and, consequently, the investigation has been started because of dissatisfaction with present methods. For that reason in the usual type of betterment investigation, it is well to put in the second column the things which are fundamentally wrong at present, so that these will be clear before the attention at all times and in devising new methods they may be avoided.

In the experimental type of investigation, where future results will be anticipated in the solution, the second column can be used to advantage in listing the things to avoid; but it will be seen that logically this carries out the same type of analysis, for the things to avoid in the future become matters that are wrong when considered in the past.

In the third column are entered briefly the main things to be done in order to overcome the wrong conditions found or avoid those things which are undesirable. The chart will not aid an individual in developing his constructive imagination or increase the fertility of his ideas. That he must do through other means. It does, however, visualize the results of his mental activity and is often an instrumental aid to the development of further ideas.

Last but not least, in the fourth column are to be entered the results which can logically be expected from putting into operation the points which are recommended. Each of these points should be developed to its logical conclusion, and then taking all the points together, it should clearly be shown how they are going to be coordinated and what the entire results will be from putting the ideas into operation. Then one has a clear picture of the whole subject which simplifies the solution of the problem itself and the selling of one's ideas to those who have the power to accept or reject them.

The foregoing represents a typical analysis of a problem. It is done mentally, in many cases, but there is a great advantage to charting the steps as outlined above. By so doing, the power of the eye and the strength of impressions gained through the eye are added to the powers of the mind, and the whole procedure of analysis becomes more clear and conclusive. Once the investigator gets in the habit of charting his analysis of a problem, he will subconsciously make use of it whenever he comes up against any kind of a difficult situation. And it will be surprising how this chart method of attack will help solve any kind of problem. It may be true that it will be necessary at

times to modify the headings of the chart somewhat to fit the specific problem, but the fundamental principles are the same.

PRACTICABILITY ESSENTIAL AT ALL TIMES

In concluding what, because of the nature of the subject, must necessarily be an inadequate treatment of the working out of solutions, it is apropos to quote from a recent interview with Thomas A. Edison. Speaking of the fact that the average individual does not utilize his imagination sufficiently, he says: "Don't be afraid to dream, but:

1. Be sure that the idea itself is right; examine the objections without prejudice, and demonstrate it to yourself.
2. Subject it to the conditions of use; learn all the arguments and weaknesses that impair its value, and be sure it stands up under the test.
3. Remember that there is a right time for putting the idea over; don't be too early or too late.
4. Be sure the idea stands up under the profit test; that it will save time or money, or earn, or do something so much better that it will warrant junking some equipment that may already be in existence for doing the same thing in another way.
5. When you come to demonstrate your idea, be sure that you are prepared to show its merits completely and conclusively; don't expect others to accept the idea as soon as you half-explain it.
6. Above all, if you are certain that the idea is sound, let nothing discourage you; go ahead with it in spite of all that people say. You know. They guess.

These and many other questions of a similar character, but peculiar to the problem itself, should be asked by the investigator in order to make sure that his recommendations are practicable. If emphasis were to be laid on any one point, it would be upon the fact that any recommendations covering improvement within an organization must be tempered to the capacity of the organization that will have to utilize them. Many plans, which have on paper

seemed ideal, fail in actual practice because the individuals composing the organization have not been capable of grasping and carrying out the ideas effectively.

On the other hand, while it is to be presupposed that the recommendations will be tempered to the physical capacity of the organization, perhaps a certain degree of emphasis on this point should be introduced at this time. The instalment of new equipment, the abandonment of an old building and the erection of a new one of a better type, a complete change in marketing methods, the abandonment of certain office equipment in place of other equipment more up to date, any of these may represent an ideal solution in order to get the very best results.

However, the company may not be financially situated to handle the expenditures required to put the plan into operation; the time element may be such as to call for some immediate results, whereas the plan proposed, while ideal, would require several years in order to get into effective operation. These and many other points of expediency are encountered and must be satisfactorily taken care of in the recommendations.

It must be remembered, further, that vital changes are difficult to put across. It is more practical, in the long run, to get a wedge in at points where the least friction will be encountered. Having a few wedges in place, others can be inserted at psychological points later, and in that way the recommendations put through with the least opposition and with the greatest probability of getting practical results.

Ideas superimposed from above or outside, no matter how practical, logical, or desirable they may be, are always taken with a feeling of resentment, no matter how slight that might be. We are all of us egoists to a greater or less degree. Our children, our radio, our car, our house, anything that we ourselves have a part in producing, is much better than that which some one else has or produces.

The investigator, in devising his recommendations, there-

fore, and laying the foundation for putting them in effective operation later, will do well to recognize this fundamental characteristic. He will do well to forego some of the credit which he might secure in order to get his ideas across.

A very practical way is through getting on a friendly basis with the executive who will have to carry out the recommendations. Talking over the problems with them, it is not difficult to weave in your ideas, not in a dictatorial manner, but diplomatically, as though some of these ideas were originated by the executive himself. In a conversation where the discussion is back and forth, it is difficult for the memory actually to recall exactly who has made any particular statement and afterwards many of the points discussed will linger and take root just as though they were the children of his own mind.

Then when at the next talk with this executive these ideas are brought up and further discussed, he considers them as his own or as something he has played a part in producing, and he stands back of them for purely personal reasons.

To a considerable extent, any one engaged in investigational work of the betterment type must be an educator. He is introducing advanced ideas, and in order to get these ideas across, he must be able to demonstrate the benefits to be secured from their adoption. This is teaching in its true meaning and, consequently, some of the ideas which have been found helpful in the practice of pedagogy will be found useful in developing and putting through recommendations.

One of the most important of these is the fact that it is not wise to give the individual more than he can digest and assimilate. In developing his recommendations and presenting his reports, he should have this in mind at all times. His recommendations should not be so radical as to arouse hostility. They should be just one step in advance. True, it may be that in the end a very radical change may be

necessary, but that radical change is best reached by a series of steps rather than at one leap.

The natural human tendency is to resist change. Routine in any business is equivalent to habit in the individual, and every one of us knows how hard certain habits are to change. By introducing such changes gradually, like dropping off a cup of coffee a day, friction within the system is avoided and the same result is obtained through making only slight changes in routines and methods at any particular time.

The second advantage to this method is derived from the fact that the individuals who must carry out the changes will have less to learn at any one time. The bulk of their work will still be along old routine lines and they will have only a little of the new to assimilate, whereas if they are given an entirely different set-up, the spirit rebels, even though orders are carried out, and it takes a longer time to get full cooperation.

In all cases, in developing recommendations the executive or engineer must bear in mind that methods can be improved no faster than the capacity of the individuals within the organization. It is useless, therefore, to attempt to graft highly improved methods upon a second-rate organization. These methods may have been fine in a high type organization. Conditions, operations, and all other physical factors may be parallel, but if the individuals who are to carry out the improved methods are lower in intelligence or ability, it is folly to expect equivalent results unless the means are provided for educating the individuals in the organization up to the point of understanding and appreciating the proposed methods.

With the working out of the solution, the investigational procedure on the advisory type of investigation ceases, and as in the case of the fact-finding type, all that remains is to prepare a report showing the results of the investigation and the recommendations, which will be discussed in the next chapter.

XVIII

PREPARING THE REPORT

What are reports? Kinds of reports. Oral reports. Written reports. Structural elements of reports. Functions of the various elements. Importance of reports. Essentials of a good report. Critical analysis of a typical report.

THE report is the culminating feature of an investigation. Reports may be defined as official statements informing, explaining, or advising relative to certain facts. No investigation, however simple, is complete until such a summary has been prepared, whether this summary or report is made mentally, orally, or in writing.

Take, for example, the every-day business problem which calls for executive decision. Quickly the executive determines what facts he needs, brings up, from the store-house of his memory, records of previous experience, and supplements these by reference to papers or by questioning subordinates. The facts thus gathered are rapidly summarized, tested, and conclusions drawn. The whole procedure from start to finish may take but a few minutes or even seconds but it is not complete until a definite report has been prepared by the mind which sums up the findings and formulates the decision.

In the foregoing report, the entire action is mental. In those investigations where the work is being done for some one else—a superior officer, client, governmental body, and so forth—the report must assume tangible expression. It is not enough that the investigator shall have satisfied himself as to the practicability of his solutions. He must be able to convince others. He must be able to set forth his findings either orally or in writing, so that those interested may know how the problem was attacked; the facts dis-

covered and their significance; the conclusions or solutions evolved and their probable value.

When the occasion is informal or the problem is simple, the usual form of report is somewhat as follows: Mr. Superintendent notes on his tickler file that a report is due from his assistant on a problem assigned to him sometime previously. Sending for him, he plunges at once into the matter by asking:

"What did you find out about those delayed orders?"

To this the assistant replies:

"Sixty-five per cent of the delays were the fault of Department X, 15% due to shortage of material, 12% due to customers' changes, and 8% miscellaneous."

"What's the matter with Department X?" the superintendent then asks.

To which the assistant replies:

"A number of men have been off sick, but principally the fault is in the inefficient methods of assigning work. Jobs get sidetracked too easily and no provisions are made for segregating and handling as special those jobs which are behind schedule when they come to the department or which get behind for any reason while in the department."

"Well, get after this and let me know in a couple of days what you think should be done" may then be the decision formed by the superintendent from the facts as stated by his assistant.

While the oral form of report has its advantages by reason of its flexibility, simplicity, and the fact that the particulars receive immediate and concentrated attention, nevertheless if the matter reported upon is in any way important, it should be made in writing. This is desirable if for no other reason than to give the facts and suggestions permanency. Reports made verbally are easily forgotten or misconstrued. Therefore, even when conditions seem to make a verbal report desirable, it should in most cases be followed up with a written report, putting the information in permanent form for future reference.

Written reports assume two usual forms: (1) the informal letter or memorandum, and (2) the formal report. The distinction between these cannot be clearly defined,

but in the main the former is used in the ordinary exchange of information from employee to superior and informal reports to outsiders where the recipient only is vitally interested or when the information is simple or brief in character. The use of the formal report, on the other hand, is usually confined to lengthy, technical, or complex matters where a number of interests are involved.

For example, a few days after the conversation quoted previously, the assistant recommended the use of a planning board in Department X to route and schedule the work. He was told to go ahead and install one and to report results monthly as soon as it was in operation. The first monthly report was as follows:

To Mr. Superintendent Date May 1, 19—
From Mr. Assistant
Subject: Operation of Planning Board in Department X

The planning board which was installed sometime ago in Department X is now in effective operation with the following results:

1. A reduction of 63% was effected in the number of orders behind shipping schedule. When the board was installed, there were in the department an average of 300 orders which had passed the shipping schedule. On April 30 there were 110 orders behind, of which less than 50% were due in any way to Department X.
2. Production has been increased, as is evidenced by the gain of 180 orders and which is further shown by the increased output report of Department X, which is shown on the shop report.
3. Increased control. Orders are fully differentiated. Those behind schedule can be given special attention.

It is too early as yet to estimate the gains which will accrue from the use of a planning board in Department X. Weekly reports show that we are constantly gaining on the number of orders behind schedule and at the rate of gain it is safe to promise that by the end of May we will be up to date with the possible exception of a small handful which, because of the type of work, are apt to get behind schedule under any conditions.

This promise is contingent, of course, upon an equal volume

of orders received in May as in April. If the number of orders received is less, the promise can be bettered somewhat; if more, we may not be able to gain quite as rapidly as indicated.

(Signed) Mr. Assistant.

Later, increased volume of business called for increased shop facilities, but before going ahead with the erection of a new building and the purchasing of new equipment, the management wanted to be sure that this expenditure was absolutely necessary. A firm of consulting engineers was employed to investigate the problem and make recommendations. After some weeks' close study, this firm presented an elaborate report to the president, consisting of 155 typewritten pages giving in detail the facts found, the conclusion reached, and the recommendations made.

It may seem a far cry from the simplest type of report just described to the more involved and complex reports just mentioned. However, the difference is in extent only. Fundamentally, they follow the same methods of transmitting information, explanation, or advice on a subject, just as surely as the investigation itself follows a more or less set procedure.

STRUCTURAL ELEMENTS OF A REPORT

As with the latter, however, by reason of difference in the character of the problem, the occasion, or the personalities calling for information, variations are often necessary in the arrangement of the elements and in some cases certain of these elements may be combined or perhaps eliminated. However, the fundamental characteristics of all reports are clearly shown by breaking down a typical formal report into its obvious divisions, which are the following:

1. Title page
2. Foreword or Preface
3. Table of Contents
4. Summary of Conclusions and Recommendations
5. Body

6. Appendix
7. Index

Not every report contains all of these elements nor is the order here given always followed. The nature of the facts reported may call for a different arrangement, as in the case of purely descriptive or informative reports where the sequence is frequently title page, foreword, body, and conclusion, with rarely the necessity for a table of contents, appendix, or index.

Likewise in many simple explanatory or advisory reports, the table of contents and index may be omitted because the number of topics discussed may be so few and the discussion so brief and direct as to make these unnecessary. An example of this is the assistant's report just quoted where the title page, preface, and table of contents are combined in the heading, and the summary and body are one. No appendix or index was required for obvious reasons, unless a shop report were attached in order to verify the statement made as to increased production.

In like manner, requirements as to the occasion or the personality for which the report is prepared may dictate a different arrangement from that given. These changes are to be expected and constitute no violation of the structure. The report must convince, and if in order to accomplish this any element has to be omitted, expanded, contracted, or placed in any position, such action must be taken.

FUNCTIONS OF THE VARIOUS ELEMENTS

The elements given, however, are so common to the usual type of investigational report that a description of the function of each and illustration of how they are used is desirable.

The *title page* should concisely but accurately state the subject of the report. Considerable care should be given as to the wording of the title and to the arrangement of the words so as to make the most pertinent features stand

out prominently. Even in the simplest reports, a heading at the top stating the subject is always to be recommended. This action classifies the report and facilitates filing and reference.

The *foreword* should briefly state the nature of the problem, the aim and purpose of the work undertaken, and the value which it is hoped will accrue from the work. This may be a separate section in the formal report, such as the preface of a book, or it may be a statement in the opening sentence of a simple report in which the purpose, scope, or limitation of the report is expressed.

The *table of contents* is really an outline of the subject-matter contained in the body of the report. It is not placed in this position because it is necessarily read next, for, as a matter of fact, this is rarely done. However, executives who get the most out of reports as a rule do read the table of contents before plunging into the main body of the report. By so doing, they get the proper perspective of the matters discussed and are able to give them due weight and consideration. In simple reports, the table of contents is frequently omitted or combined with the foreword and summary of conclusions or recommendations.

The *summary of conclusions or recommendations* should succinctly state the essence of the report so that the reader can quickly find out what it is all about without having to wade through a mass of detail. This summary is desirable in all types of reports except, perhaps, those of an expository character, as, for example, a report describing a new process of making cement. With this possible exception, there is always a gain in briefly summarizing the findings at the beginning.

One of the most important advantages is that of time saving. Even the most hurried reading of the summary gives the reader at a glance the principal features which will be developed in the report. If he agrees with the recommendations or conclusions entirely and is pressed for time, he need give the body only a cursory glance. If he

disagrees with certain of the recommendations, he need give the balance of the report only a cursory inspection and confine his careful study to that portion with which he does not agree at the time. Of course, if he does not agree with any of the suggestions or conclusions, he will want to go carefully through the entire body of the report and then form his decision.

But regardless of the reader's reaction to the recommendations or conclusions, by setting them forth at this point he has an opportunity to get the salient points in the minimum of time, and this feature in itself is sufficient entirely to justify the arrangement.

The *body* of the report comprises the full statement of the investigation showing the details as to what was discovered, the action which was taken, the analysis made of the facts, the conclusions drawn, the recommendations made, and the benefits which should be secured from carrying out the recommendations. The body of the report should closely follow the outline given in the table of contents, but because the content matter depends entirely on the nature of the investigation and the facts found, no general recommendations can be made as to internal structure except those given later in this chapter under the heading of "Essentials of a Good Report."

The *appendix* contains the supplementary matter which is necessary to a full appreciation of the body but which if included in the body would tend to break the continuity of treatment. Nothing should be taken for granted as proved in the body of the report unless full proof is given either in the body itself or in the appendix. In simple and short reports an appendix is rarely needed but it is present whenever charts, maps, or records of any kind are attached to a report as supplements or for verification purposes. In most reports of any importance, an important feature of the appendix should be a bibliography of the books read or authorities consulted in connection with the work.

The *index* is an alphabetical arrangement of the topics

which are discussed in the body of the report, giving the number of page on which the matter is taken up. It is particularly valuable in reports covering general problems, especially when they are long or discuss a number of different matters, even though closely related to the problem.

In shorter reports, especially those of an informal character, an index is seldom necessary. Nor is it necessary in even longer reports where the table of contents classifies the subject-matter minutely. In a very large number of the reports prepared by governmental departments, the table of contents and the index are, to all intent and purposes, combined in this way.

However, the index is a very useful device at all times as it facilitates the utmost use of the report and whenever a distinct gain can be effected or ease of consultation is promoted, it is to be recommended that a topical index be provided.

Before concluding the discussion of the structural elements of a report, one other valuable adjunct should be taken up—*the letter of transmission*. This, while seldom a direct part of the report, yet should be considered with it, inasmuch as it is frequently used in addition or in place of the foreword or preface.

The most satisfactory way to present a report is to hand it in personally. This affords the opportunity of selling the one for whom it has been prepared with its value or at least calling attention to certain vital features which should be interesting enough to insure that he will read the entire report. The letter of transmission is the next best means of introducing a report. It is essentially an informal letter which accompanies but which is not a part of the report itself. Its function is purely that of arousing interest and desire to make full use of the report.

The sequence of writing the various parts of the report is another matter that deserves attention. Although the arrangement of formal reports follows pretty closely the sequence given, yet the facts themselves are not prepared

in that order. Actually, the report is written in this order: body, appendix, summary, table of contents, index, foreword or preface, title page, and letter of transmission.

IMPORTANCE OF REPORTS

In the early days of business, when contact between executives and subordinates was direct and when businesses were not so far flung, reports did not assume the importance that they do now. Necessary details could be secured quickly by asking questions or by sending out to get necessary supplementary information. Today executives in even the smallest establishments must depend upon reports for the major portion of their information regarding the operations of their business and possibilities for improvement.

A recent interview describes how Judge Gary uses reports to run the United States Steel Corporation:

> He discovers what new ideas are going to lead into by having an investigation made by experts, and on the facts found by experts he forms his judgments. Every policy is thus determined. Affairs thus come to him in report form, although usually supplemented by the personal narrative of the investigator. He does not often actually go on the ground. If he attempted to see in person what was going on in every branch of the steel corporation, he would be traveling two-thirds of the year and would lose his perspective.

Notwithstanding the unquestioned importance of reports as the information bearers of industry, it is nevertheless a fact that the files of practically every concern are full of reports which have failed in their mission. That is, there are thousands of reports presenting ideas of real value that either have not been read or have not been acted upon favorably. Not only, therefore, must a report have information of value to convey, but it must convey that information in such a way as to convince. What, then, are the essentials of a report which induce the reader to read it in order to find out the facts which it presents?

ESSENTIALS OF A GOOD REPORT

The answer to this question is that important as is the structure of the report, after all the flesh and blood part is the way it is written. Of two reports on the same subject, identical in structure, one is read and carries convinction; the other is ignored. And at the same time the treatment of the matter in the second report may be ever so much more thorough and the conclusions more practicable.

A report, to have any value, must be read to be comprehended, and it should produce conviction and induce favorable action. If it fails to interest, if it fails to convince, it is a failure, no matter how scholarly may be the research work or how logical the deductions.

What are the essentials of a good report? Chiefly they are:

1. It must be accurate as to facts and sound as to conclusions or recommendations;
2. It must be prepared from the standpoint of the reader;
3. It must include only those matters directly pertinent to the subject;
4. It must be carefully divided into parts and the parts must be logically arranged;
5. It must be long enough to cover the subject properly but not so long as to become tedious;
6. It must be interesting in style, easy to read, clear in statement, concrete in illustration, and attractive in appearance.

These essentials of a good report have been prepared from the standpoint of written reports, whether formal or informal in character. However, the same essentials apply to the oral report, it being only necessary to substitute the word "listener" for "reader" in the discussion hereafter given and the pertinency of the observations will be obvious.

1. *Accuracy and Practicability in the Report.* Little emphasis need be given at this point to the fact that the report must be accurate as to facts and sound as to con-

clusions or recommendations. Obviously this follows if the work of investigation has been thoroughly done. With this statement of an obvious essential, further discussion is needless.

2. *The Reader's View-Point.* Before attempting to write a report on any subject, it is essential to clearly visualize the person or persons who will read the report. Is it to be read by the general public or by an individual or group of individuals possessing an equally comprehensive interest in the subject as the writer? Between these two extremes there are all sorts of gradations.

A report which is intended for general consumption must be presented in such a way as to enable the average person to grasp its content. On the other hand, if a report is to be presented to a technical society or to a board of engineers, or even to a superior officer who possesses a thorough understanding of the matters covered, there is excuse for phrasing it in a technical language and for presuming that certain technical matters will be thoroughly understood, thus requiring little or no definition or explanation.

Preparing the report to fit these two extremes presents no radical difficulties. It is the group of readers between these extremes that cause the trouble. Therefore, the writer, beforehand, must clearly visualize his audience and determine just how much understanding of the subject can be presupposed and just how far he will have to go in explaining details. Realizing the limitations of his audience, he can then write his report in such language that it will readily be understood.

Right here it should be emphasized that no matter how technical a report may be, it can be written so that the average man can easily comprehend the points taken up. Huxley's lectures on science are excellent examples in point. In these lectures the most fundamental laws of nature are explained so simply that the average working man can grasp their significance.

What Huxley did in the field of geology and natural

science, the engineer writing a report on a business subject can even more easily accomplish because he can assume a certain general understanding of the subject which was not true of Huxley's audience. The only danger he must avoid is in overestimating the profundity of that knowledge and in consequently assuming an understanding on certain phases which does not exist.

For quite another reason the writer must get the reader's view-point. He must be able to imagine how he is going to react to certain criticisms that will perhaps be made or to certain suggestions, recommendations, or conclusions that will perhaps be contrary to the present beliefs of the reader.

Quite frequently very admirable reports, accurate in detail, splendid in arrangement, and sound in the conclusions and recommendations, have failed to be adopted simply because the criticisms made, suggestions offered, or conclusions drawn were worded in such a way that, instead of convincing the reader of their truth, they aroused his opposition.

Of course, it may be said that the report should be taken for its real value and that the reader is very narrow-minded who lets false pride or feelings rob him of the benefits which he would derive from adopting valuable ideas. But human nature being as it is, one must expect the reader to be swayed to a considerable extent by his emotions; and, consequently, in wording the report it is absolutely necessary to phrase very carefully any criticisms or comments apt to be considered in the slightest degree unfavorable.

Of course, any recommendations for change are bound to stir up opposition, but there are many ways of saying the same thing. It is said of a famous statesman that he could say "No" so tactfully that the office-seeker could not take offense but left feeling just as friendly toward this statesman as though he had gotten what he asked. This is probably a little exaggerated, but the fact remains that it is possible to so phrase criticisms that instead of being

taken as such they will be thought of as suggestions and adopted with little or no opposition.

Getting the reader's view-point is perhaps the most important essential of a good report, for by so doing, the way is cleared for an appeal both to his intellect and his emotions in addition to avoiding the pitfalls which exist from partial understandings, misunderstandings, or hostile reactions.

3. *Unity in the Report.* Unity means oneness of composition. There is unity in a report when the problem has been clearly outlined and when everything included in the report is pertinent to the problem. Unity is violated in two principal ways, as follows:

(*a*) When extraneous matter is introduced into the report, regardless of how interesting this information may be. For example, in a report on a method for securing increased production in Department X, unity would be violated by including recommendations on the redesign of certain parts, even though that redesign might simplify production. For the purpose at hand, the product should be considered as it is and plans prepared on that basis. The redesigning of the product and the benefits secured from the production standpoint should be the subject-matter of a separate report.

(*b*) When details which break the continuity of thought are incorporated in the body of the report. This is one of the most frequent violations of unity and makes many an otherwise good report hard to read. When, for example, it is desirable to refer to certain statistics as to output, population, and so forth, it is good practice to include in an appendix statistical tables where these data can be given in full. In the body of the report the necessary deductions or conclusions only should be stated and reference made to those tables or data in the appendix that verify the statements.

In order to avoid violating the principle of unity in

either of these ways, it is often advisable to start off the report with a statement such as this: "The problem to be considered in this report is the following" or "It is my purpose to show the following." This type of handling is especially adapted to informal reports, such as letters or memoranda. In the longer formal report it is equally advantageous to state the purpose, this being done in the title page and amplified further in the table of contents and foreword.

4. *Coherence in the Report.* Coherence means sticking together. Good unity comes from a careful selection of details; good coherence comes from the careful arrangement of these details. Suppose an automobile is taken apart and the parts are thrown on a pile. This pile of parts has unity, for every piece belongs to the car and nothing is included in the pile that does not belong to it. However, it cannot be said to have coherence.

Coherence comes in the report only through careful planning. It was emphasized in the beginning of the investigation how necessary planning was in order that the work might be quickly and profitably carried on to a successful conclusion. It is equally effective at this time in order to make sure that the data thus collected and analyzed are presented in the very best possible form. There is good coherence in a report when:

(*a*) It is carefully divided into parts; and,
(*b*) The parts are logically arranged.

Take, for example, the book you are reading. Without setting it up as a model, nevertheless in preparing it constant attention has been given to the demands of coherence. In the first place, the investigational procedure itself is broken down into parts as outlined in Chapter II. Each of these parts has been broken down into divisions, and a chapter has been devoted to the consideration of each important division. A study of each of the chapters will show that it is further broken down into parts and these divided

and subdivided still further whenever the complete treatment of the subject has required it.

5. *Proportion in the Report.* Proportion in the report calls for assigning to each element its true value and giving it the correct amount of attention. Good proportion is perhaps the easiest of the essentials to achieve. In collecting the facts and subsequently weighing and testing them, the relative importance of the data is pretty well established, and consequently, in writing up the report one has a rather definite idea as to how much space should be given to the various matters.

Sometimes, however, through oversight or other considerations, details regarding certain facts will be included in the report that really do not matter but only make the report bigger without strengthening it in any way. Such violations of the law of proportion are usually called "padding."

There are occasions, of course, when the padding is purposely inserted in order to make the report seem consequential. In fact, the writer has seen a number of examination reports which were mainly padding, the report being obviously made up largely from standardized material which was evidently used over and over again. In some instances there is excuse for such practice; but rarely is this the case, for the very utilization of this method of preparing reports makes it easy to overlook consideration of proportion, and unconsciously irrelevant matters will be included.

In connection with the consideration of proportion, the problem of length comes up inevitably. How long should a report be? The facts involved, the reader's view-point, unity, coherence, and proportion to a certain degree influence, if not determine, its length, but not entirely. In fact, there is no set law as to length except that *it should be long enough to cover the subject and not so long as to become tiresome.*

However, there is a distinct value in brevity, for, other

things being equal, a report which briefly yet clearly and concisely records desired information stands a greater chance of being read and therefore of fulfilling its mission. To be sure, the reader does not have to read all the report if it is properly constructed. The summary gives him the meat and he can skip such portions as he may desire without feeling that he has sacrificed anything. But the summary, valuable as it is for giving a bird's-eye view of the report, cannot replace the body of the report which must be so prepared as not to become unduly tiresome.

In those cases where a long report is necessary and there is some question about its being read in its entirety, a practical expedient that often works is to divide up the report into short sections and present these separately. The final report, in such cases, becomes a summary report that ties the whole work together.

6. *Style in the Report.* The style of writing which is natural to the writer means much in getting his message across. His style, after all, is the expression of his personality. If it is interesting, easy to read, clear in statement, concise in treatment, concrete in illustration, and if this work is attractive in appearance, the chances are greatly in his favor. Lacking in any of these respects, while it perhaps may not be fatal, it will adversely affect the readability of his report; and if it is not read, how can the findings be appreciated?

The report should be interesting. Even the driest subjects have their points of interest and these should be carefully sought out and developed. There is some excuse, perhaps, for preparing a dry report when it is to be read solely by a group of technical men. But even the most profound intellects occasionally lose interest, and by making the report interesting, still greater value is given it and its possibilities of acceptance are greatly increased.

And this is even more true of the average business report. Here the writer is not even sure that his report will be read.

He must make his points so interesting as to invite reading, understanding, and adoption.

An easy style is usually a matter of practice. Composition is hard for most people, and few men of the type usually engaged in research work are naturally gifted with a facile pen. Perhaps the most practical way to cultivate an easy style is to write naturally just as though talking. Unconsciously, most every one adopts a stilted style when writing. If the thoughts to be expressed were phrased verbally first of all and then written down just as spoken, the gain would be apparent. Try this method and an easy style will naturally develop if sufficient practice is given.

Clearness is certainly an essential element of style. Clearness calls for clear thinking. Clear thinking results from correct observation, accurate weighing of evidence, and logical deduction. Constant attention to the carrying out of the procedure of investigation in the proper way cannot but result in clear thinking which ultimately winds up in clearness in presenting the facts in the report.

Concreteness in style is aided by the frequent use of illustrations and examples. The value of graphical presentation is fully established, and whenever possible, ideas should be pictured, described, or explained in such a manner as to make them self-evident. Summaries, tables, indentations, frequent paragraphs, underscoring, or the use of different sizes of type are some of the most important aids to making the idea concrete as well as making it stand out in such a way that it is easily remembered. For example, the subject-matter of this book is naturally abstract and requires constant effort in order to keep the attention on it. In order to make the points stand out, note, throughout, how various mechanical devices have been utilized, such as frequent paragraphs, tabulation of points covered, detailed classification of divisions, italics, summaries, variation in type size, indentation, and so forth.

Much could be written on the subject of making reports attractive. Standard usage has practically decreed that

the 8½x11 inch size is preferable because this fits in standard filing equipment. Most reports are typewritten, although they may be later printed. In typing them, allow ample margins for notes or comments. A good practice is to have the left-hand margin 1¼ inch, the top and bottom margins 1 inch, and the right-hand margin ¾ inch.

Mention has been made before of breaking up the subject-matter into frequent paragraphs and the utilization of capitals, italics, and underscoring in order to bring out important points. To this may be added the fact that all reports should be double-spaced in order to facilitate reading.

Such, then, are the essential requirements of a good report, and if these are observed it is possible to write an interesting and yet authoritative report on almost any subject which will not only cover the subject adequately but will induce favorable action, which, after all, is the purpose underlying its preparation.

CRITICAL ANALYSIS OF A TYPICAL REPORT

Perhaps the clearest way to bring out these essentials is to illustrate by a typical report taken from the files of one of our large industrial establishments. In selecting a "horrible example," it would be relatively easy to find reports that failed of their mission because of defects of structure or content matter and as a consequence were not read. Failures in these respects are obvious; so in selecting a report to illustrate the importance of these essentials, preference was given to one which actually was read and which aroused interest and induced action, but yet failed to convince.

In the early part of January, 1923, the president of a large concern manufacturing office appliances sent a general letter to his salesmen asking them to take especial note of a new type of advertisement appearing in a certain periodical of national circulation and to write him any com-

ments or suggestions which might occur to them regarding the advertising policy of the company.

One of the leading salesmen wrote the president a rather lengthy letter or report incorporating his ideas on the subject of advertising their product. This report is so typical that it is reproduced intact with the exception of omitting, for obvious reasons, those parts which would indicate the concern from whose files it has been taken.

Dear Mr. Blank:

I realize my views on the subject must, of necessity, differ very radically from those of the expert advertising agency producing your advertising. I claim, however, that I am actually engaged in selling what you are advertising and have been so engaged for over eight years, and I have a thorough conception as to the line of talk which will strike home to Mr. Prospect.

In advertising, as in personal solicitation, 50% of the sale is made in *the approach.* A sale, either prospective or real, is made by that which is first intelligently conveyed to the prospect's mind along the lines which are of interest to him.

The advertisement in question gives absolutely no inkling at first glance of the value of our product. The heading of the advertisement, "The Foundation of Bigger Business," is too much in line with every device on the market today, which practically says: "Use me or my system and I will increase your business." I can just about picture where I would get off if I used any or all of the phraseology of this advertisement as an approach on a prospective sale.

It is my further belief that, if a little more careful study of local conditions are gone into by your advertising agents when advertising in such localities as New York City, much better results would be possible. I think their selection of the *New York Times* showed a decided lack of knowledge of the territorial conditions for the article advertised. The class of people you must reach with such advertisements is that which is not only interested in, but capable or authorized to pay $30 for, an office appliance.

The big majority of readers of the *Times* are not such, but rather just the opposite. Those who read such a paper are the average, every-day man or woman looking for news, or when looking for advertising of any nature, it is usually of the department-store bargain and not for advertisements of office appliances.

Advertising our product through mediums of this kind can only be successful and productive of results when you are advertising in mediums which cut out the every-day reader, and which reach only business men or business concerns who are interested in the aid which our appliance can give them, and when so interested are capable of placing an order.

In this city we have such publications as *Men's Wear, Women's Wear, The Daily Trade Record, The Wall Street Journal,* and others, any or all of which reach an exclusive class of people and are published daily. There would be very little waste circulation with any of the above papers for your proposition for reasons already stated.

Another point it seems to me that should be emphasized is the advisability of strengthening our competition against ———, especially in New York City, which is its stronghold. Yet in your *Times* advertisement, nothing was said or done to especially bring out the fact that ours is a competitive product. In fact, in the first advertisement a very valuable space was left blank which could have been utilized for this purpose.

I have some very practical ideas on the subject of advertising and will be glad to meet with the representative of ——— Advertising Agency, and give him some ideas which I think are both practical and could be easily carried out.

I also believe that in national advertising better results can be obtained by advertising in trade publications along lines of interest to the particular trade in question. There are many excellent publications, for example the *Chicago-Herald Gazette,* which has a nation-wide circulation. I am not, however, an authority by any means as to which publications of this class are most likely to give the best results, but this can be established through careful analysis of its circulation.

The *Chicago-Herald Gazette* reaches many wholesale concerns, but a study of its circulation would also probably reveal the fact that it reaches many thousands of retail haberdashers, which latter would be dead circulation for our purposes.

Having read my criticism, you will probably now want to know what I propose to do to remedy it, or what I think should be done. Our products, as they refer to office aids, are too highly specialized in their scope and character to permit of their being advertised in a general sense. What I mean by this is that the product may be used for certain purposes, or if it is properly suggested to him, the prospect will use it for a certain purpose. This is true with every distinct line of business, and this thought

must be quickly and intelligently conveyed to Mr. Businessman. If by a salesman, this must be done by one who knows what he is talking about; if by advertising, something which will touch the eye and create a mental vision of that something which will aid Mr. Businessman in the conduct of his affairs.

It is my opinion that the quick mental grasp of the value of our product, which you wish to convey home to prospective purchasers, is tremendously weakened by the decided lack of intelligent and constructive suggestion as to why the product should be of value to him. I enclose a rough diagram of my idea of an advertisement. Possibly some of the text of the advertisement under discussion might fit in with it. I do not say that this advertisement is all bad. Unquestionably good results will come from it, but that does not mean that a possibility for increasing the efficiency of your advertisement should be overlooked or discarded. In the enclosed diagram I have endeavored to bring out some of the most important reasons why a prospect should buy. It would never do for me to simply tell a man "I have something here that means the foundation of a bigger business for you" without explaining carefully to him its particular value for his particular purpose.

I of course realize that in advertising you must appeal to the multitude, but it is also possible to advertise with judgment and so segregate the various values of the advertised article that it will appeal to the individual's interest. Our product is not like a typewriter which everybody uses for the same purpose. Although used primarily for certain purposes, it can be used for many others, and your advertising, to be 100% successful, must make an appeal to the diversified people who can use it for a large number of different purposes.

The other day I called on the United States Rubber Company, sales department, and was informed that my man, the assistant sales manager, was tied up at a combined meeting of the entire sales force and advertising department. I learned that the two-million dollar appropriation for advertising United States Rubber products for the coming year was being threshed out before the selling force of this concern; that no advertisement was o. k. for the press before the entire sales force had an opportunity to pass on the merits of its get-up and "punch." I think a concern that does that is pursuing the only real way of getting the right kind of "dope" for its advertisements. It may take an expert advertising agency to trim off the rough edges of the salesman's ideas, but the salesman generally knows what he is talking about. ———might very well follow the footsteps of the United States

Rubber Company in this respect. What manner or method you choose to adopt to bring this about is, of course, for you to decide, but the interchange of sales ideas from those who actually do the selling should be worth a great deal if properly utilized.

(Signed) J. F. JONES.

Taking up this report for study, the first thing to be noted is the fact that it is somewhat difficult to get a clear-cut idea of just what recommendations have been made. Presumably, the conclusions and recommendations which are in the mind of the writer are sound, but he has not presented them in such a fashion as to prove conclusively that he is right.

Essential Number 2 is not conspicuously violated, for the president, being actively in charge of advertising and sales, can be expected to understand fully the points which have been made by the salesman. However, his—the president's—point of view is not fully realized or otherwise the letter would not have started off with the negative opening which did much to prejudice him against the ideas later developed. Not only that, but throughout the report occur statements and comments that are worded so bluntly or undiplomatically that they are bound to arouse a negative attitude.

This report does not directly violate Essential Number 3, inasmuch as the subject is very broad, consequently giving considerable range to the salesman's comments. A study of the report will bring out the fact that two specific matters are discussed which perhaps could have been better treated had they been discussed in separate reports or at least discussed in separate parts of the same report.

In structure the report is weak. The letter does not give the subject at all, so that in order to file the report it must first of all be classified by the executive reading it. The first paragraph is really the foreword, and while it acts in that capacity, it is a very poor example of a foreword; instead of selling the executive on reading the report, it is tactless in wording and has a tendency to set up a nega-

tive reaction. No table of contents is perhaps needed in such a report as this, but a summary of conclusions and recommendations would certainly improve it greatly. The body, as stated before, could be well divided into two parts, discussing the major points brought out. No appendix or index, of course, is necessary. So much for consideration of the division of the report into parts and the arrangement of the parts.

The report, in view of the strong statements made, is not sufficiently long. Too many statements are made without adequate proof being advanced. Consequently, these statements can only be accepted as expressions of personal opinion and do not lead to conviction. The report would be considerably stronger had definite proofs been attached to verify each one of the positive statements made regarding this concern's advertising policy.

The report is interesting in style. It is easy to read, and it is clear from the salesman's statements that he has made a definite study of the subject and knows what he is talking about. However, as stated before, while the report was read, it did not convince the readers, which fact will be brought out by a quotation from the advertising agents, to whom the president turned over this letter for reply. Their letter to the president regarding the ideas brought out in the preceding report is as follows:

Dear Mr. Blank:

This man Jones, who wrote this letter, expresses the universal view of the uninitiated in advertising. Because he sees certain publications in certain aspects, without a definite knowledge of their influence and their use, he comes to the conclusions which he is not in position to arrive at on the basis of practical value.

It is very true that papers like *Women's Wear*, *Men's Wear*, and the *Daily Trade Record* reach an exclusive class of people. There are lots of other papers that do the same thing, but they reach exclusive people for exclusive purposes and when you get beyond the sphere of that exclusive purpose, advertising has proved to be ineffective.

We have had sufficient experience in seeing such things as adding machines, office appliances of one sort or another advertised

in papers of just this type and in some of these very papers mentioned by Mr. Jones in New York City because some one had an idea that here was a 100% field, and had not considered the other factor I have mentioned above. But none of these campaigns ever paid.

On the other hand, years of experience have shown that the way to reach the real buyers of New York City in the most economical way, when it comes to anything of a commercial or business nature particularly, is to use the *New York Times*. We have seen this proved on business books, adding machines, typewriters, desks, card systems, and so forth.

It may be true that a lot of people who read the *Times* could never buy or would never buy a ——— at $30, but nevertheless the *Times* does reach by far the largest percentage of real business men in New York City. It reaches the very people that these special trade papers reach in lesser degree. A newspaper like the *New York Times*, with its strong news columns, its strong financial pages, its excellent market pages, and so forth, is an outstanding example among American newspapers.

It must also be remembered that the man who pays for a ——— or the man who pays for an adding machine is not always the man who uses it. It is generally some employee whose work requires such an article who is the factor that starts the sale movement, and the man who pays the bill is in many cases only the man who approves rather than the one who suggests.

A paper like the *Wall Street Journal* might be used as a supplemental factor to the *New York Times*, just as you would use the *Journal of Commerce* or the *New York Commercial*. All three papers would be supplemental factors, but they would not be chosen before the *Times*.

This man also says that he also "believes that in national advertising better results would be obtained by advertising in trade publications along lines of interest to the particular trade in question."

It is quite evident that he has never had any experience in advertising in trade publications, nor has he been a very keen observer of how trade publications are subscribed to and read in the office of the average subscriber. This entire presentation on the part of Mr. Jones in the matter of mediums is a very primitive one and shows an utter absence of knowledge of the function and values of trade papers.

(Signed) ADVERTISING AGENTS.

Here is an example of a report that was read but which did not result in conviction. It represents an inestimable amount of waste, for as it turned out, the salesman in the main was right. The advertising campaign having failed to turn out as expected, this salesman, two years later, was brought into the main office in order to put into operation some of the very ideas that he had previously tried to get adopted through letters and reports. Had he been able to present his ideas in a more convincing fashion, he might have saved his concern many thousands of dollars and increased his own position and earnings in proportion.

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